



Ontario Department
of Education

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Man, Science, and Technology

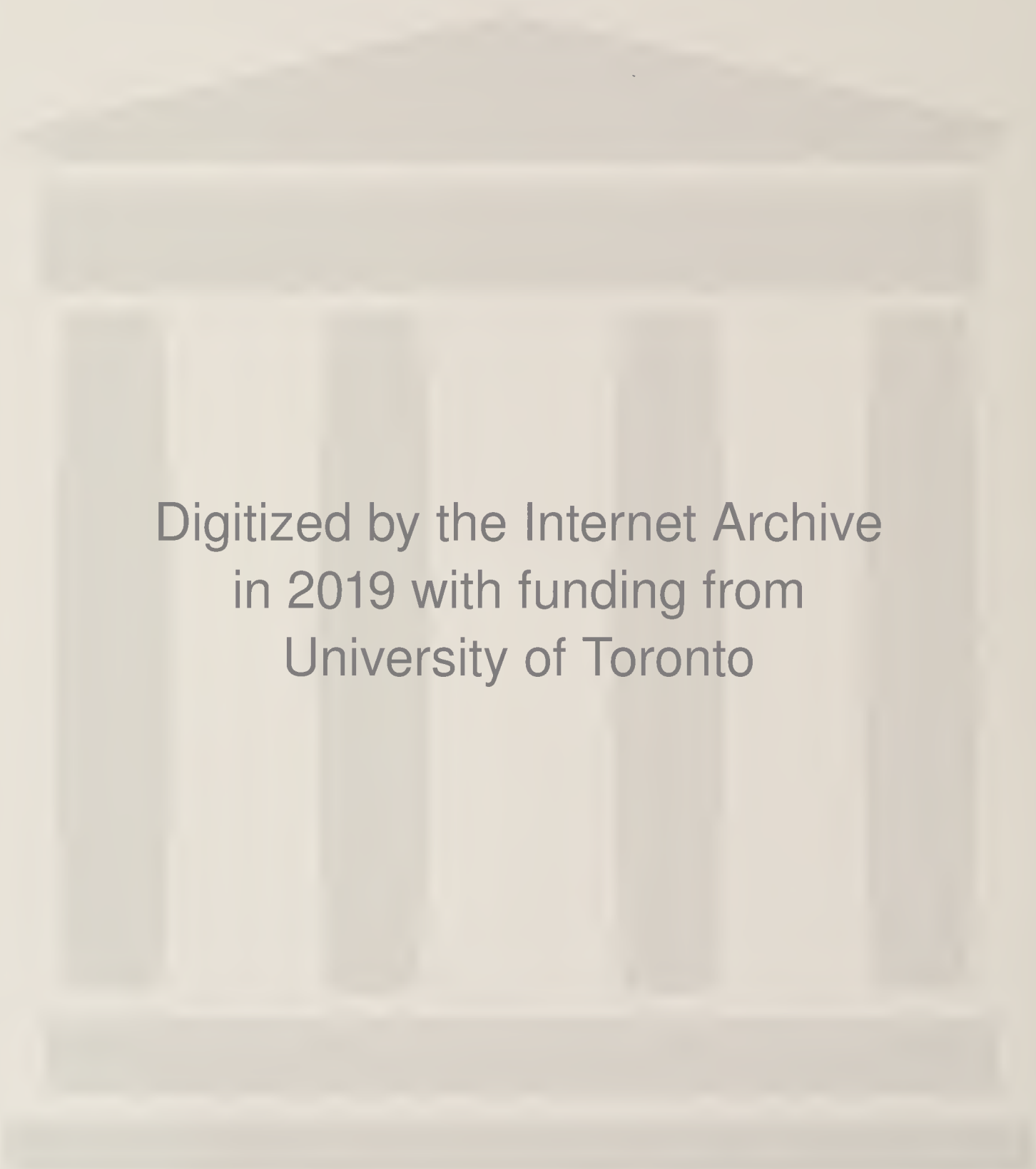




Ontario Department
of Education
1972

Man, Science, and Technology

A guideline for the Intermediate and
Senior Divisions dealing with the
interaction of man, science, and
technology, both past and present.



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Nature and Objectives

Man, Science, and Technology is a basis for courses intended to give interested students some insight into the influence of science and technology on human affairs and, conversely, the influence of human affairs on the development of technology and science.

In the modern world no product of the human intellect exerts so profound an influence on the human condition or is so capable of altering it for better or worse as science and technology.

The release of this guideline authorizes the development of Intermediate and Senior Division courses with the objectives indicated. Such courses may be offered in any one or in all years of the Intermediate and Senior Divisions, including the Secondary School Honour Graduation year, and when offered in a secondary school, will carry diploma credit proportional to the time and work required.

The specific courses developed from this guideline which are being offered for credit towards the Secondary School Honour Graduation Diploma must be submitted for approval to the Regional Offices of the Department of Education as outlined in Circular H.S.1. and Circular 14.

A major purpose of courses developed from this guideline is to enable students to develop the feeling that they are better able to evaluate and respond to changes in technology and concomitant changes in human affairs. Hopefully, the knowledge gained of scientific method and of the past history of technological solutions to human needs will lead students to a greater readiness to accept solutions as temporary and subject to change and to a greater willingness to suspend final judgement.

Another major objective is the development of intellectual abilities and skills. The subject matter of this field provides innumerable opportunities for developing skills of interpretation, application, analysis of relationships, judgement, and synthesis. The difficulty will not be in identifying these, but in choosing from amongst them.

The knowledge objective of the course is to develop some insight into the reciprocal interactions of science, technology, and human affairs referred

to in the opening paragraph. The mastering of a large body of detailed knowledge concerning the topics studied is unlikely to further this insight. While a grasp of specifics will be necessary during discussion of a topic, their retention is unnecessary.

Courses should, instead, try to develop an awareness of the major principles and generalizations in the field. They should lead to recognition of the way in which human desires and aspirations provide motivation in scientific and technological enterprises and how these enterprises help satisfy human needs while creating situations in which further needs become apparent.

The student can emerge with some insight into scientific method and of the creative process involved in the development of science and technology. He can begin to understand some of the factors that affect the development of technology and, conversely, some of the ways in which technology has affected and continues to affect human culture. He should draw some conclusions as to the process by which this occurs and gain some recognition of the fact that the influence of technological achievements and scientific theories and doctrines often extends far beyond their ostensible subjects and may have profound and unexpected effects on human thought and action.

From this *Man, Science, and Technology* Guideline, dozens of topics can be chosen, consideration of any of which could be equally effective in achieving these general objectives. Accordingly, no specific course is outlined and no specific body of subject matter is set down as the major element. Instead, topics suitable for varying age levels, interests and abilities have been compiled and, as a practical guide, suggestions are offered as to how one of these might be treated. The wide, but by no means exclusive, list of possible topics is therefore not prescriptive, but has been included to provide the greatest possible opportunity for the teacher and the class together to select course material that engages their interest and imagination.

The purposes of the guideline will be achieved more through the processes developed by teacher and student than by the study of any particular body of subject matter.

Designing Local Courses

Organization of Courses

One reason for the introduction of this guideline has been to create a situation in which the artificial divisions that usually separate disciplines are broken down. It would be contrary to the spirit of this document if planning and presentation were to be limited to the resources of a single subject or person.

Ideally, instruction should be offered by the teachers who have organized the course. If this cannot be arranged, teachers not involved in the actual presentation of courses should be involved as resource people. For example, when a course is under the aegis of a teacher of history, it should be standard practice for him to refer his pupils to a science or technology teacher for help with scientific or technological concepts. Needless to say, the librarian and staff of the resource centre are also prime resource personnel.

Time Allotment

The distribution of time for courses developed from this guideline will vary from school to school and from year to year within a school, depending on the nature of the topics pursued. For example, large blocks of time in one term may be preferable in some circumstances to a uniform distribution of weekly periods during a school year. Before any definite timetable commitment is made, consultation with the course organizers is strongly urged.

The time allocation for courses should, in general, be proportional to the credit value assigned in schools using a credit system. The credit definition in *Circular H.S.1*, for secondary schools, requires that for each credit claimed, work be successfully completed “that normally would be completed after 110 to 120 hours of scheduled time”.

Location within the School

The location for students and teachers to work within the school can vary with the choice of topics. In many cases, a conventional classroom will suffice. A room with a demonstration desk would allow students and teacher to demonstrate some experiment related to the topic. Certain topics might be better presented in laboratories or technical facilities.

Even if laboratory and technical facilities are not required for group use, they may be required by individuals who wish to follow up some of the ideas encountered in practical terms. The library and resource centre of the school are equally necessary both in scheduled time and during the student’s uncommitted time.

Provision for Community Activities

In many cases, depending on the topics chosen, students can profit from out-of-school activities both in school time and on their own.

Visits to museums of science or technology or museums related to local industry will be particularly useful. Some are listed in Appendix A.

Out-of-school work, however, should not be confined to museum visits. The entire community is a learning resource. A class or individual student investigating the effect of technological change on a community might visit the municipal archives, the registrar of deeds and master of titles, or local industries. Talks with members of the local historical society might be useful. In some cases, students might observe and investigate remnants of former industrial activity—an abandoned railway embankment, dam, or factory.

Local libraries are prime resources and their use should be encouraged.

The richness and accessibility of these community resources are important factors in determining choice of topics and time allocation. If the community is rich in these resources, a half-day block of time might allow the student to leave the school freely without interfering with other scheduled subjects.

Learning Materials

Appendix B contains a short list of films that may be useful with some of the topics listed.

The list is not exhaustive but, as in the other appendices, is intended to give some idea of the range of material available.

New films in the areas of interest of this guideline are constantly becoming available. Teachers are advised to scan the announcements of the distributors and the various film library catalogues as they appear.

In addition to films, an increasingly rich array of non-print resource material is available from a variety of sources, and teachers should be on the lookout for these.

As students will often be discussing aspects of history or science or technology in which they have had little or no systematic grounding, every avenue to understanding must be utilized. Films, filmstrips, slides, projectuals, tapes, and recordings are particularly appropriate and effective communications media for the topics in a course. Their use should be routine and regular and should not be confined to class use but made available for individual study.

There is a large and extensive body of literature in the fields of interest of this guideline. A very limited selection of this material is contained in Appendix C, which begins on page 22. The references are annotated, and all the materials listed were in print in 1971.

Department of Education Assistance

The program consultants in the regional offices, particularly those in the fields of history, science, technology, and intermediate and senior education, are prepared to give assistance in the formulation of objectives, the design of courses, the establishment of appropriate methods of evaluation, and the organization of courses within the school. If such assistance is desired, the appropriate regional office of the Department of Education should be contacted.

Region 1/Northwestern
303 News Chronicle Building
Water Street
Thunder Bay "P", Ontario
(807) 345-6551
(807) 344-3541

Region 2/Midnorthern
1349 Lasalle Boulevard
Sudbury, Ontario
(705) 566-3480

Region 3/Northeastern
P.O. Box 3020
North Bay, Ontario
(705) 474-7210

Region 4/Western
759 Hyde Park Road
London 73, Ontario
(519) 472-1440

Region 5/Midwestern
279 Weber Street North
Waterloo, Ontario
(519) 885-0440

Region 6/Niagara
15 Church Street, Suite 402
St. Catharines, Ontario
(416) 684-1123

Region 7/West Central
40 Eglinton Avenue East
Toronto 315, Ontario
(416) 365-2692
(416) 365-5026

Region 8/East Central
Heron's Hill Building, Suite 3201
2025 Sheppard Avenue East
Willowdale, Ontario
(416) 491-0330

Region 9/Eastern
1082 Princess Street
Kingston, Ontario
(613) 546-2641

Region 10/Ottawa Valley
1825 Woodward Drive
Ottawa K2C 0R2, Ontario
(613) 225-2230

Evaluation

If one of the major tasks of evaluation is to assess the extent to which course objectives are being met, then obviously the method of evaluation must be appropriate to these objectives. In the section, "Nature and Objectives", some possible course objectives were stated. The question of which is to be emphasized, and to what level of attainment, can only be decided with reference to the needs, interests and maturity of each group or preferably each individual taking the course. For some, attitudinal goals may be paramount; others may wish to make the course a vehicle for the development of intellectual skills and abilities. The nature of the evaluation must differ greatly in the two cases.

The student's personal commitment will be much greater if he has helped select the course objectives. Students must therefore be closely involved in their selection and in the formulation of the methods used to determine if they have been successfully attained. In this process, the group may come to a consensus to which all may willingly subscribe. If this does not happen, teachers might consider requiring each student to state his course objectives and negotiate a series of "contracts" regarding these objectives and appropriate methods of assessment. In this process the teacher must constantly try to ensure that the contracts arrived at are consistent with the student's ability and realistic in terms of his long-range objectives. The ultimate decision as to what will be accomplished rests, as it always has, with the student, but he should be left with no doubt as to whether the standard he sets for himself is appropriate to the standards the real world is likely to require of him.

If this individual mode of contracting for objectives is pursued, many conventional evaluative procedures become inappropriate. The common test or examination with a common marking scheme would give way to individual assignments evaluated to

standards defined in the individual contract. Assessment becomes a continuous process throughout the year rather than a formal operation occurring at stated intervals. Although more continuous attention is required from the teacher, the advantages of this system are many. For the teacher, they lie in being able to feel that the wide range of abilities and aspirations in the group are being effectively dealt with; for the student, in the feeling that his individuality is being recognized in a significant way.

In courses based on this guideline, skill development should receive a higher priority than the massive acquisition of facts. The facts that are to be assimilated should be broad concepts and generalizations rather than detailed and highly specific information.

Detailed information should be used only as scaffolding to build general concepts, to be shelved when the concept has been grasped. Or it may become a vehicle for developing skills such as testing for relevance, deployment of evidence, generalization, and synopsis. Only rarely, would it have value sufficient in itself to make its acquisition a prime objective.

Because fact retention tests are easily designed and marked and can be reasonably objective, it is tempting to base a major portion of the evaluation on them. Teachers should resist this temptation. Has the student neglected any major line of evidence? Has he been critical in his sources? Has he summarized effectively? Has he generalized in appropriate ways? How relevant to the point at hand is his information? How effectively and logically has he organized and deployed this information? How effective is the presentation? How well is a coherent argument or point of view built up? The assessment of factors like these is admittedly more difficult and more subjective than a simple assessment of

fact retention. But only if such factors are assessed and given major weight in the total evaluation, will the evaluation be consistent with what, for many, will be the major objectives of the course.

In addition to these cognitive objectives, many teachers will formulate affective objectives. For many students these may be the prime objectives, with only very nominal achievement sought in the cognitive area.

A teacher is more likely to recognize in a student a need, say, for a greater toleration of opposing points of view than is the student to recognize this need for himself. Thus affective goals are more likely to be set by the teacher than by the student, and the evaluation of progress towards these goals is more of an aid for the teacher in the design of a course than a factor in assessing the success or failure of the student. This will be based on the attainment of cognitive objectives even though these may be only nominal. Although it may be hoped that a student will become more tolerant, or more sceptical, or more willing to suspend judgement, it is hardly fair to deny him credit for the course if his exposure to it has failed to have this effect. The teacher, however, must take note of this result and, if significant, use it as evidence to help decide whether, and in what direction, the course should be modified.

The evaluation of progress toward affective goals is perhaps the most difficult and subjective of all types of assessment and is therefore the least commonly attempted. However, for certain students success in these goals may be by far the most important outcome, and in these cases some evaluation must be attempted. Although this evaluation is difficult and subjective, teachers may feel greater readiness to attempt it if they remember that the results are for the assessment of the course, not the student.

Some Possible Topics

The list that follows is intended to suggest topics from which a course might be designed. It is only a random selection and teachers should feel quite free to suggest others. The list, however, is an indication of the breadth and scope possible.

Some of these topics could profitably sustain an entire year's work; others only a few weeks. In no case should two or three days be spent on each of the sixty-one listed topics. Such a course would be superficial in the extreme. It is suggested that in general a year's work might include work in from one to eight topics.

In selecting topics, the following factors must be borne in mind: availability of resource materials, relation of topics to out-of-school resources, physical requirements within the school, overlap with topics in courses previously or concurrently studied, the relation of the topics to each other, and, most important of all, the interest, ability and maturity of the students. *It follows that students should take an active part in selecting topics, with the teacher advising as to practicality, extent, difficulty, and appropriateness in relation to the objectives chosen.*

The topics are in three groups. The first, "Man: Scientist and Technologist", deals with the lives of individual scientists and technologists.

A biographical approach is implied and emphasis is placed on the man himself, his character, his education, his cultural and social background, and his personal achievements and their influence in the society around him.

The topics of the second group, "Man Understanding Nature", deal with science and its development. Some are concerned with particular episodes, others with an entire branch of science. The emphasis is not on the contribution of a single individual but on the collective contributions of many, linking together to create the fundamental understanding on which our ability to manipulate nature is based.

The topics of the third group, "Man Solving His Practical Problems", illustrate how the understanding gained in the scientific process is used by man to solve what he feels to be his immediate problems. The corollary point, that the solutions to these immediate problems nearly always create additional problems of a social or cultural nature, will be well illustrated in many of the examples suggested.

The numbers in brackets following each topic refer to resource materials listed in the appendices. Again, these are only an arbitrary selection and do not necessarily include all the applicable references.

Group A - Man: Scientist and Technologist

Faraday

Sir Michael Faraday's researches remain, even today, a model of the experimental method in science. His work in electricity led directly to the discovery of the electric motor and generator and to the great deployment of electrical energy that characterizes the modern world. (11, 28, 30, 34, 69, 70, 75, 88)

Oppenheimer and Galileo

These two great scientists faced trial because their attitudes as scientists were in conflict with the attitudes of the societies in which they lived. Galileo, the foremost astronomer of his day, was tried by the Church for heresy and forced to recant for teaching that the earth revolved about the sun. More than three hundred years later, Oppenheimer, a theoretical physicist and director of the Los Alamos Laboratory which pioneered the development of the atomic bomb, underwent a senatorial investigation of his loyalty. The backgrounds and circumstances were very different, but many parallels can be found. (39, 77, 233, 259, & F6)

Banting and Best

Banting's award of the Nobel Prize for the co-discovery with Frederick Best of insulin, and hence of a cure for the once-fatal disease diabetes, was the first major international recognition of scientific achievement in Canada. A contrast of the conditions under which they worked with those enjoyed by present-day researchers provides an instructive example of how Canadian society's attitude to scientific research has changed. (12, 166, & F4)

Antoine Lavoisier

A French aristocrat, victim of the Revolution, and founder of modern chemistry. (73, 119)

Archimedes

The world dominated by classical Greece was not so obsessed by the purely theoretical as is often supposed. A biographical treatment of Archimedes, mathematician, physicist, engineer, and philosopher, will reveal much of the inventiveness of the ancient world. (171, 192, 205, 206 & F2)

Watchers of the Skies

Man’s view of the universe, and hence of his own place in it, is perhaps more affected by the findings of astronomy than by those of any other science. A study of the lives and work of some of the world’s great astronomers will reveal how our view of the universe changes and how society’s reception of the astronomer varies from country to country and period to period. Included among those who might be investigated are Tycho Brahé, Johannes Kepler, Copernicus, Galileo, William Herschell and Edmond Halley. (14, 32, 33 ,34, 42, 63, 101, 107, 113, 125, & F6)

Charles Saunders

This Canadian plant geneticist developed new strains of wheat which made the Canadian prairies one of the world’s great granaries. Modern plant geneticists, continuing the kind of work engaged in by Saunders, offer the most likely solution to the problem of feeding the world’s expanding population. (166)

Sir Isaac Newton

Newton’s genius has been acclaimed by some of the leading figures in English literature. Wordsworth described him as,“a mind forever voyaging through strange seas of thought, alone.” Alexander Pope saw him as another Prometheus: “Nature and Nature’s laws lay hid in night; God said, Let Newton be! and all was light.” Blake wrote, “May God us keep from single vision and Newton’s sleep.” Newton said of himself, “I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.” (26, 31, 44, 107, & F10)

Norbert Wiener: Father of the Computer Age

Wiener invented a new branch of science called cybernetics, for dealing with the mechanisms of communication and control in machines. His theoretical insights led to the modern electronic computer. (86)

Leonardo Da Vinci: Renaissance Man

As well as being a great artist, Da Vinci was a design engineer of insight and inventiveness. A study of this aspect of Da Vinci’s work will reveal that his genius as a technologist was at least as great as his ability as a painter. (62)

Louis Pasteur

A biologist whose work remains a model of the experimental technique, Pasteur investigated with equal interest and success problems as diverse as spontaneous generation, the prevention of rabies, the reason for the souring of wine, and why certain substances form right- and left-handed crystals. (12, 48, 54, 71)

Edison, Marconi, and Bell

Three inventors whose ideas revolutionized the techniques of communication, and with it, our lives. (47, 66)

Sir Ernest Rutherford

The founding genius of the atomic age, Rutherford laid the basis of our understanding of the atom and its nucleus. (43, 79, 82, & F15)

Brunel

A flamboyant personality, Isambard Kingdom Brunel was the greatest engineer of his age. He built England’s Great Western Railway, the world’s first tunnel under a river, and, at the time, the world’s largest steamship, the *Great Eastern*. (81, 90, 95, 262)

Sir Humphrey Davy

In an age before specialization became essential, Davy was outstanding as a chemist, a physicist, and a practical technologist. Above all he recognized the importance of communicating to the public the results of scientific inquiry, and helped develop the Royal Institution for that purpose. (68)

Sir Francis Bacon

Although he lived in the pre-scientific age, Bacon became the founder of modern science by advocating observation and experiment as methods of arriving at the truth. (3, 45)

Madame Curie

The discoverer of the radioactive elements, Marie Curie was the first woman to gain international renown as a scientist, and in so doing opened up scientific careers to women generally. (5, 49)

T. H. Huxley

A friend of Darwin and public spokesman for the ideas of evolution, Huxley was one of the leading scientific figures of his day and a teacher whose work led to the general adoption of science as a subject in the secondary schools. (15, 65)

Sir Charles Lyell

Lyell was a founder of modern geology whose books influenced Darwin and whose life illustrates that of a typical man of science in nineteenth century England. (35)

Otto Hahn, Frederick Jolliot-Curie, and Enrico Fermi

Three scientists from Germany, France, and Italy, whose work was fundamental to our understanding of nuclear fission and hence to the release and control of atomic energy. (37, 53, 61, 79)

Darwin and Wallace

Darwin, in South America, and Wallace, many years later in the Malay archipelago, independently but from similar evidence deduced the theory of evolution and its mechanism by natural selection. Their lives reflect the biological science of their era. (50, 51, 52, 57, 59, 87, & F3, F12)

William Harvey

The court physician of King Charles, Harvey discovered the circulation of the blood and in so doing became one of the founders of experimental biology. His life provides a good account of medicine in Stuart England. (67, 71)

Group B - Man Understanding Nature

Models in Science

Scientists continually devise “models” or explanations of how a system or structure is built and how it operates. A successful model must account for all the facts and must serve as a basis for prediction. If new facts are obtained which cannot be explained by the model, the model must be changed. Thus the earth-centred model of the solar system had to be replaced by the sun-centred model after the work of Copernicus and Galileo. Thompson’s model or concept of the atom was displaced by Rutherford’s, Rutherford’s by Bohr’s, Bohr’s by the wave-mechanical model. Each successive model explains more observations than does its predecessor and leads to more accurate prediction. A good illustration of the scientific method can be obtained by tracing the progressive changes in a scientific model and the reasons for these changes. Models are used in all branches of science, but those dealing with the solar system, the universe, heat, light, electricity, or the atom are probably the easiest to document. (124, 136, 174, 178, 207, 237, 255, 260, 261, 284, & F15.)

The Development of Science

This topic could be treated as a general sketch or outline of the history of science or it could focus on a specific period or age of science, exploring the age as a whole and the place of science in it. Thus the ancient world, the Middle Ages, or the seventeenth, eighteenth, nineteenth, or twentieth centuries could be central themes. Alternatively, developments in a single branch or group of related branches could be traced. (89, 94, 97, 116, 126, 129, 131, 132, 152, 160, 171, 174, 182, 183, 205, 206, 284).

Relativity

This was a revolution in scientific thought which modified our view of the universe as profoundly as did the contributions of Copernicus and Galileo. (156, 175, 240, 258)

Mathematics: The Language of Science

Mathematics has always been the servant of science, providing a means of expression so exact and concise, and so capable of revealing new meanings and relationships, that scientists continually strive to express their results in mathematical form. But mathematics has had a life and development of its own, independent of, although often prompted by, the requirements of science and technology. As such it has at various times deeply influenced philosophy, social science, religion, literature, and art. (223, 234, 235, 265, 276, 277, 278, 282, & F18)

Scientific Societies

Science is based on the collective contribution of many individuals. Without free interchange of information, it cannot grow. The modern age of science, the period of its greatest success and development, flourished when men of science banded together to form societies and research institutes as means of communicating their ideas and furthering their work. An investigation of the histories of some of the scientific societies will illustrate the impetus their formation provided. (41, 151, 180, 186, 221, 278)

The History of Medicine

In no other field is the relation between basic scientific knowledge and its practical application to aid human suffering so evident and direct as in medicine. (115, 139, 158, 165, 169, 293, & F8)

The Telescope and the Microscope

These two instruments have been vital to the development of science. Based on similar optical principles, one looks outward to the heavens, the other inward to the microcosm. The history of their development parallels the development of astronomy and biology and shows how inextricably “pure science” and “technology” are linked. (161, 173, 232)

The Evolution of Physical Concepts

The student of physics customarily begins his study by accepting certain basic concepts as fundamental and then proceeds to learn how to work with them. But these concepts, like all ideas, have had a long evolution in men’s minds. A study of the evolution of some of these key concepts will show that they have not only been influenced by observation and experiment but by prevailing philosophies and social doctrines. (103, 114, 127, 152, 174, 207, 222, 237)

The History of Biology

How have our ideas concerning the nature of life and living things altered since the Greeks first invented biology as a distinct branch of science? (91, 128, 134)

The Politics of Science

The efficient utilization and management of science is essential in modern technologically based societies. The story of the interaction of science and government is a fascinating one. (92, 216, 231, 250, 268)

Plants and Civilization

The first civilization became possible when men learned enough about the growth of plants to be able to cultivate them successfully. This kind of applied botany is still the basis of our world society. (154, 164, 243, 290)

Astronomy: The Most Ancient Science

With its roots extending to the astrology of the Babylonians, astronomy was perhaps the first branch of natural science to be systematically studied. No other science is so closely connected to our superstitions, our religions, and our view of ourselves. (101, 113, 118, 125, 136, 138, & F17)

Genetics and the Control of Heredity

Our understanding of the nature of inheritance is based on the work of Mendel and is now finding its ultimate explanation in the work of the molecular biologists. We have already used this understanding to create new kinds of plants and animals tailored to human needs. Potentially, we can use this knowledge to manipulate our own heredity and create new kinds of men and women. The possibility creates enormous ethical and social problems. (12, 24, 189, 257, 274)

Chemistry: The Transformation of Matter

The laws that govern the transformation of matter have fascinated men from the beginning of recorded history. Chemistry is the systematic study of these transformations. The alchemists hoped to transmute base metals to gold. They never realized this hope, but modern chemists have discovered other transmutations of matter which have created such wealth that whole nations have been built upon it. (104, 111, 119, 122, 228)

The Concept of Evolution and Its Effect on Human Affairs

This topic can be a vehicle for showing how a major scientific idea can have far-reaching effects on human thought and action in other fields. Some of the issues involved might be introduced by a study of the Scopes Trial, making use of the play and feature film on it. (149, 211, 244, 281, & F23) The work could then focus on the idea of evolution itself, showing the gradual emergence of the concept in western thought and paying special attention to the evidence that convinced Charles Darwin of the fact of organic evolution and that led him to advance the theory of natural selection as its explanation. (8, 18, 29, 35, 50, 51, 52, 87, 91, 128, 129, 159, 190, 195, 217, 239, & F3, F12)

The topic might conclude with a study of the influence the ideas of evolution and of natural selection have had in fields such as world politics, economics, and social attitudes. (262, 270, 271, 272, 275)

General references (6, 7, 57, 59, 155, 157, 199, 238, 249, 264)

Unlocking the Structure of the Atom

The discovery of the structure of the atom has been a great collective intellectual achievement of western man. The gradual accumulation of evidence and deduction reads almost like a detective story, and the *dramatis personae* include such giants as Dalton, Avogadro, Cannizzaro, Berzelius, Mendeleev, Thompson, Rutherford, Millikan, Moseley, Geiger, the Curies, Planck, Bohr, and Schrodinger. (207, 220, 255, 260, 261, & F1, F15)

Style and Personality in Science

Every great scientist has a personal style that moulds his work and gives it character and individuality. A study of some of these scientific “styles” will show that there are many approaches to scientific understanding and that the intuitive and creative intelligence, with all its variations, is called into play at every significant turn. (163, 177, 191, 197, 231, 233, 247, 268, 269)

The Conscience of Science

It is commonly supposed that the scientist’s pre-occupation with his work for its own sake makes him indifferent to its social or moral implications. This is seldom the case. In fact the scientist’s greater knowledge often makes him more aware of, and concerned by, its implications than those around him. (152, 162, 176, 189, 191, 231, 233, 239, 280)

Group C - Man Solving His Practical Problems

Behind Everything: The Chemical Industry

So basic are the products of the chemical industry that a nation's annual consumption of sulphuric acid is often taken as an index of its total industrial activity. First based on trial and error and later on a sophisticated understanding of scientific chemistry, developments in the industry at certain periods in a nation's history have sometimes made the difference between poverty and prosperity and between peace and war. The following themes might be explored: modern explosives, their total effect, good or evil, the role of men like Abel, Nobel, and Weizmann; the relation between food production, chemical fertilizers, and pesticides; the achievements of a chemical engineer like Ludwig Mond; the soda industry; Leblanc and the French Revolution; the relation between Ostwald's process for oxidizing ammonia, Haber's process for making it from the nitrogen of the air, and Germany's capacity to sustain the First World War. (105)

The Stirrup and the Feudal System

The stirrup found its way to Europe from the Middle East at the beginning of the eighth century A.D. This technological innovation was one of the major factors leading to the development of the feudal system, on which the entire social organization of the Middle Ages was based. (290)

Energy, Power, and Prime Movers

It is man's ability to harness and control forms of energy other than that of his own muscles that makes a modern society possible. How did we come to understand and use these sources of energy? (167, 187, 202, 219, 241, 283, 285, 290)

Rome's Greatest Material Gift—Cement

Cement was a Roman invention. Its discovery made possible not only the masonry structures of Roman times but the medieval cathedrals, and buildings, humble or great, ever since. (192)

The Wheel

Why are wheels round? When was the wheel first invented? To what use was it first put? Has the wheel added more to human happiness than it has subtracted? Is there any substitute for the wheel?

Flight: From Da Vinci to the Wright Brothers to the Moon

The basic principles of flight were understood by Da Vinci in the sixteenth century. It took four hundred years for western technology to develop the materials and power sources necessary to give reality to this vision. (62, 85, 169, 213, 214)

Cloth to Clothe Us

Starting as a home-based craft, the textile industry was the first to which machinery was applied on a large scale. Its mechanization marked the beginning of the Industrial Revolution and all that sprang from it. (19, 105, 172, 201, 283)

The History of Electricity and the Generation of Hydro-Electric Power

Ours is an electrical age. But the widespread deployment of electrical energy that characterizes the modern technological society was possible only after we began to understand something of its nature and behaviour and how to produce and distribute it. The history of the practical utilization of something as basic as electricity fits into scarcely more than a hundred years. (219, 263)

Metals and Their Working

Men have mined for metals since history began. Whole ages have been characterized by the metals they used. Wars have been fought and countries explored and developed to find and control their sources. The history of metallurgy touches our own at every turn. (105, 146, 148, 194, 224, 225, 226, 227)

Watering the Land

Irrigation is one of the most ancient branches of civil engineering. Civilizations have risen and fallen on the rise and decline of irrigation systems. (145, 192)

Moving Man and His Materials

The development of transportation from horse to hover-craft has continually reflected the advancing tide of western technology. Students might undertake a general survey, or concentrate on the development of a particular type of transportation, or investigate the effect of some new transport link on the economic, social, and political life of a region. The building of the CPR or the Bridgewater Canal in England are good examples to begin with. (105, 169, 185, 187, 198, 202, 203, 241, 242, 266)

Plastics

Modern chemistry has created a new range of substances that are gradually replacing traditional materials. What are they? Why do they exhibit such a wide range of properties? What might be the economic and social effects of their increasing use? (179)

Two Sides of the Same Coin

Knowledge by itself is morally neutral. Man, however, has the capacity for good or evil. The knowledge or power he gains can therefore be used for good or evil purposes. Knowing man to be imperfect, should the scientist and engineer refuse to advance knowledge or pursue technological innovations? Nowhere is this dilemma more evident than in our knowledge of the structure of the atom and its nucleus. The fundamental discoveries investigated in this area are among mankind's crowning intellectual feats. This knowledge leads directly to:

1. Power from the Atom

Producible in quantities potentially great enough to supply man's energy needs forever, atomic energy may be a source of unlimited good. (150, 176, 200, 220, 229, 236, & F1)

2. The Bomb

This application of atomic energy produces a destructive power potentially great enough to completely destroy life on earth. (150, 176, 218, 231, 254, & F19, F25)

Question for Debate

Knowing what we know now, if you had been on the Board of Governors of McGill University in 1905, would you have voted to continue support of the research on radioactivity and atomic structure engaged in by Ernest Rutherford and his associates?

Craftsmen and Craftsmanship

Prior to the Industrial Revolution, almost all production of man-made objects was carried out by craftsmen working individually or in small groups with journeymen and apprentices. Totally responsible for the design and execution of their work, these men achieved a kind of beauty, perfection, and satisfaction in their craft that industrialization and mechanization, with its division of labour, has destroyed. (245, 248, 251, 253)

The Lathe: The Social Implications of Its Development

For a possible treatment of this unit see page 14. (62, 80, 83, 90, 95, 100, 102, 112, 117, 130, 251, 252, 273, 283, 285, 292)

Communications

Professor McLuhan, in his studies on the relation between the means of communication and what is communicated, has shown how profoundly technological changes in the means of communication modify our perception, condition our logic and thought, and influence our social and political life. (105, 187, 212, 230, 241, 283, & F13, F20)

Technology and the Farmer

Such simple inventions as the plough, the horse-collar, and the rotation of crops produced profound social changes in the Middle Ages. Technological innovation in agriculture continues with the increasing development of machines for the automation of farm labour, the use of insecticides and chemical fertilizers to improve yields, and the genetic engineering of new varieties of plants and domestic animals. These sophisticated changes, like the simpler ones of the Middle Ages, continue to have far-ranging social effects, especially in the underdeveloped parts of the world. (102, 288, 289, 290, & F7)

From Iron to Steel

The addition of two or three per cent carbon converts iron to steel. Apparently trivial, this chemical change produces profound differences in the physical properties of the metal. The modern era rests on steel; it could never have been built on iron. The discovery of the methods of making and manipulating steel marks a shift in our material culture as profound as that which occurred when ancient man moved from stone to bronze. (146, 194)

Automation: Its Technique, Its Sociology

“Thanks to the division of labour, this labour power becomes specialized, is reduced to skill in handling a particular tool. As soon as the guiding of the tool becomes the work of the machine, the use-value and exchange-value of the workers’ labour power disappear. The worker becomes unsaleable, like paper money which is no longer legal tender.” Karl Marx, *Das Capital*, 1867.

Marx was the first writer of consequence to point out that the machine presented not only a technical but also a sociological problem. The sociological problem is still with us, rendered even more acute by the increasing sophistication of automation. (196, 204, 215, 256, & F22)

Technology and the Environment

For thousands of years prior to the Industrial Revolution, human activity had little permanently deleterious effect on the natural environment. Two hundred years after the modern industrial age began, environmental pollution has, in some areas, reached almost catastrophic proportions. It will be a crucial test of our social and political institutions to see if they can halt pollution and reclaim its damage before the natural environment on which we are dependent is irretrievably lost. (168, 267, & F14)

The Luxury of Leisure

One of the major contributions of technology to the well-being of western man has been the provision to millions of the leisure that once only a few enjoyed. The trend is continuing and accelerating. As always in the advance of technology, we can never be sure if it will solve more problems than it creates. (204)

A Specific Example

The example that follows is included to indicate to teachers some of the possibilities in the material outlined in this guideline. This must not be regarded as a prescriptive model since the approach indicated could obviously not be adapted to all of the topics listed. It is simply a detailed example designed to stimulate thought about the process of curriculum development in this field. It is hoped that as much stimulation will be gained by disagreement with the approach chosen as by agreement and emulation.

The Lathe - The Social Implications of Its Development

The basic strategy of the unit is to utilize practical interest in a common machine tool as a means of leading the student into a wider area of interest and awareness than he may originally have possessed. One of the results should be the demonstration to the student that the tools he or others may employ are not merely mechanical devices used for a particular operation but technological innovations whose development and use have had immense human consequences.

This outcome may be of interest to students other than the technologically inclined. For this reason the topic is developed in such a manner that students with no prior knowledge of the lathe will find it meaningful. Obviously the first two sections are unnecessary for students who are already familiar with the lathe and its operation. In either case it is not an objective of the unit to develop a deep understanding of the structure of the lathe and its evolution or to produce any degree of skill in its operation. No mechanical details need be considered beyond the most basic, except when they are required in day-to-day discussion, and retention of these details is not necessary beyond their period of active use.

Introduction

Activity

I. Examine a lathe and watch it in operation. Describe its action and make a simple diagram labelling the parts and associated tools. (For this introductory activity, arrange a visit to the school shops for a demonstration of the various ways in which the lathe is used and, if possible, let the members of the group operate it themselves. If there are no shops in the school, try to arrange a visit to another school or a local industry or borrow a small portable lathe and bring it into the classroom. Diagrams and pictures, no matter how clear, cannot transmit the kind of practical knowledge of the operation of the lathe that direct experience can provide.)

Objectives

- to establish the idea of a lathe
- to give some idea of how a lathe operates and what it can do
- to identify four or five of the basic parts of the lathe as a basis for later discussion

Activity

II. Identify common objects that have been produced by some sort of lathe. Include objects that illustrate the basic operation of the lathe (turning, threading, knurling, and spinning).

Objective

- to give some idea of the widespread use of the lathe

Activity

III. Discuss the idea of rotation by considering whether activities like twisting a doorknob, turning one's head or walking in a circle are examples of true rotary motion. Does the lathe exhibit rotary motion?

Objective

- to ensure that a true idea of rotary motion is established and to associate this with the lathe

Origin and Development

Activity

IV. Machines that rotate have round shafts supported in round bearings. The development of machines to produce these shafts and bearings as well as the devices to drive and control these machines might be called the history of industrialization. Discuss this idea. Is it valid? What would we lose if everything that uses a round rotating shaft were to disappear? (285)

Objective

- to extend the idea of the importance of the lathe and to show how vital it is to industrialized society

Activity

V. No living thing illustrates true rotation of one of its parts in relation to another. The only motion natural to our bodies is reciprocating. Discuss whether this might have been a factor in delaying the invention of machines with continuous rotary motion and slowing down their dissemination once invented.

Objective

- to indicate the possibility that our receptiveness to certain ideas may be conditioned by our bodily limitations

Activity

VI. Investigate the origins of the lathe by reading sources such as Woodbury (292) and Singer (130). Compare the essential parts of one of the earliest lathes illustrated (for example, the Egyptian device shown in Woodbury [292]) with those of a modern lathe. Discuss points such as:

- the location of the rotating part
- how is the rotation produced?
- how is rapid rotation produced?
- is there a cutting tool and tool rest?

At the end of this discussion the student should have redefined and/or elaborated his concept of a lathe.

The group may be asked to speculate on how ancient peoples may have used “lathe-like” machines and why they wanted to use machines rather than doing the job manually.

In what respects might the lathe and the primitive fire drill share a common origin? the lathe and the potter’s wheel? the lathe and the simple drill? How might the idea of any of these tools have occurred to early man?

This may lead to a redefinition of a lathe. Must it show rotation? must there be cutting? does the tool or the work rotate? (95, 100, 283)

Objectives

- to indicate the antiquity of the idea of the lathe

- to help students refine their definition of a lathe

- to identify basic lathe features in various contexts

- to help students find an accurate means of expressing the distinction between related devices (as between drill and lathe)

Activity

VII. Discuss the application of the lathe in the jeweller’s art. What is the lapidary lathe used for? What cultures used and developed the lapidary lathe? Investigation of these points provides a vehicle to illustrate how the Eastern peoples often provided a link between ancient and medieval cultures.

Objective

- to illustrate a possible step in the transmission of the lathe idea from ancient to medieval times

Activity

VIII. The contribution of medieval technology to the development of the lathe was the use of the crank and the treadle to produce rotary action and the invention of the slide rest. Investigate this development in sources like Singer (130) and Klemm (112).

The explanation of how a treadle might produce rotary motion could be assigned as a project to a mechanically minded student. He might build a small working model.

Students could investigate the role of the treadle in other medieval machinery — the spinning wheel or the forge bellows, for example. Others could investigate the conditions under which late medieval machine-tool artisans worked and how they were organized. What products did they produce? How did the availability of these products change social conditions?

Objectives

- to identify some significant innovations in the development of the medieval lathe as given in relevant sources, both written and pictorial
- to give the student practice in formulating and testing his own pattern of explanation

continued

Activity

IX. Leonardo Da Vinci developed a thread -cutting lathe which was widely used. Discuss with the group questions such as:

- what is a thread ?
- what additional motion must be imparted to the lathe in order to cut threads?

Technically minded students might be interested in investigating the differences between Leonardo’s lathe and the earlier Mandrel lathe.

- what determines the “pitch” of the thread being cut?

As a project, a survey of some of Da Vinci’s mechanical inventions might be made to determine how often a thread is used. The question of whether Da Vinci “invented” or “improved” the thread-cutting lathe could also be pursued. (62, 100, 252)

Objectives

- to introduce the idea of threading and relate it to the lathe
- to provide an opportunity of broadening cultural horizons by discussing the life and times of Da Vinci

Activity

X. With ordinary lathes the quality of the finished piece depends to a large extent on the skill of the machinist. With the thread-cutting lathe the skill of the operator is less important than the care with which his lathe has been built. The group should determine what mechanical feature of the thread -cutting lathe is responsible for this. A discussion of the significance of this development should be initiated. Is this a step in the decline of craftsmanship, in the mechanization and consequent dehumanization of work?

Why is it particularly important that cutting a thread be completely mechanized? A discussion of this point might raise questions such as the importance of economic factors in fostering new developments and the ease with which machine tools can achieve greater uniformity at lower cost than can the average manual worker.

Objectives

- to illustrate one of the early steps in the “mechanization” of work
- to hypothesize on the possible social effects of this development

Maudslay and the Modern Lathe

Activity

XI. Investigate the life of the great English engineer and machinist, Henry Maudslay (80, 83), in particular his education and the way in which he came to master his trade. From what social class and religion did engineers originate in Maudslay’s time? Contrast this with present-day circumstances. What was the distinction between engineer and machinist in Maudslay’s time? What is the distinction now, both in terms of education and activities?

Objectives

- to provide a human framework for the discussion
- to make the group aware of the great differences between our society and that of Maudslay’s

Activity

XII. Ascertain some of Maudslay’s most important achievements in mechanical engineering. (80, 83, 95, 112, 273, 283, 292)

Ojbective

- to exercise skills of analysis and summarization and to prepare for sections XIII and XIV

Activity

XIII. In section XII students will find reference to Maudslay’s improvement of the thread -cutting lathe. His improvements were really directed towards greater precision and uniformity in the cutting of threads, and permitted for the first time interchangeability of nuts and bolts (formerly a given nut would fit only the specific bolt it was matched to).

Discuss with the group the idea of precision leading to uniformity, to interchangeability, and ultimately to mass production and our modern industrialized society.

Objective

- to illustrate the significance of the idea of precision, uniformity, and interchangeability, and the far-reaching consequences that proceeded from them.

Optional Topic

Activity

XIV. Another of Maudslay's achievements the group will identify in section XII is his invention of the slide rest and its application to the lathe. In the words of Karl Marx (112), "This mechanical appliance does not replace another tool, but the human hand itself."

Make sure the group has a chance to understand what the slide rest is and how it works. Then discuss the relevance of Marx's statement. Is the development significant as another step in the dehumanization and mechanization of labour and /or as an important development in the march towards greater precision with the outcome discussed in section XIII?

Objective

- to illustrate the wider implications of what may at first appear to be a relatively minor development

Activity

XV. Discuss the assertion that Maudslay's most important contribution may have been in engendering the importance of precision amongst the people who worked with and for him.

Activity

XVI. Conclude this portion of the work by discussing why we consider Maudslay a turning point. Why do we think of him as developing the "modern" lathe? In what sense was his lathe modern? Was it only in a mechanical sense or were his developments "modern" in the social and philosophical sense as well? (273, 292)

Objective

- to summarize the ideas of the unit

Activity

XVII. The effect of the lathe on furniture design might be studied. As a project, medieval and Tudor furniture styles might be contrasted with eighteenth and nineteenth century styles. The refinement of the lathe makes possible a parallel refinement in the turning of furniture legs and backs. Certain styles can only be produced with an efficient wood-turning lathe.

Objective

- to show that style and taste can be conditioned by the mechanical means available

Possible Follow-up Topics

The unit could end after "Maudslay and the Modern Lathe" or "Optional Topic", but if interest warrants could be continued in a number of possible directions. For example:

Activity

XVIII. What have been the main lines of the evolution of the lathe since Maudslay's time? Has there been any change in basic concept? How have improvements in power sources affected its development? To what degree has automation been exploited in the lathe? What are the likely directions of future development? What modern machine tools may have evolved from the lathe? What human roles are now required in a modern machine-tool factory? How do these compare with the roles required in a factory in Maudslay's time? What are the roles likely to be in the future? (90, 273)

Activity

XIX. If machines are needed to make other machines, and a new nation has no modern machines, how can it hope to become industrialized?

Activity

XX. Did the saturation bombing and dismantling for war reparations of German factories during and immediately after World War II hinder or foster the post-war rebirth of German industry?

Activity

XXI. This unit has surveyed some of the main developments in the evolution of an important machine tool. What are some of the parallel social developments that may in fact have been influenced by developments in machine tools? How has the role of the worker changed? How has his attitude to his work changed, and how has this change been reflected in the development of new social institutions?

Appendix A: Museums and Centres of Science and Technology

The list that follows contains some fifty locations accessible during at least part of the year to students and teachers in Ontario schools.

The exhibits range from modest collections illustrating some aspect of pioneer technology or local industry to elaborate expositions on science and technology, as at the Ontario Science Centre or the National Museum of Science and Technology, or to great formal museum collections of international importance illustrating the full range of human civilization, as at the Royal Ontario Museum.

Teachers organizing a course based on this guideline should become familiar with the type of resource in the list that follows and make the nature and availability of these resources a factor in the selection of at least some of the topics proposed for study.

Just as a picture can save a thousand words, a three-dimensional object can save a thousand pictures. This is especially so if the object is some sort of mechanism that can be set in motion. Teachers who do not provide for the kind of learning that real objects make possible are ignoring a vital avenue to understanding, one that all students can travel profitably and which may, for many students, be the only pathway.

All of the institutions listed can provide opportunities for this kind of learning if properly utilized. In a few of the larger ones, a staff of professional educators is on hand to help organize and conduct appropriate learning activities. In most

cases, however, it is a matter of the teacher visiting the centre in advance and deciding how best to use the materials available, just as he would familiarize himself with the books in the library or the films in the audio-visual centre.

The list that follows contains only the more formally constituted museums and collections. Teachers, therefore, should not feel that the lack of one of these institutions in their community means that there are no opportunities for learning based on observation of real objects and processes. Every community, in its farms, factories, abandoned buildings, canals, roads, and railways provides worthwhile opportunities, perhaps even more valuable because they are not artificially separated from real life as in a museum.

The dates of opening and visiting hours of the institutions listed vary from year to year. Before planning a visit teachers should check with the institution concerned. Most appreciate advance notice of larger parties, and often if sufficient notice is given special demonstrations are arranged which would not otherwise be available.

Teachers planning field trips will also find useful the pamphlet entitled *Ontario Historic Sites and Museums*. This is updated annually and is available from the Department of Tourism and Information at Queen's Park or any of its local offices. It gives the latest available information on opening dates and hours of all museums and historic sites in the province.

M1. Algonquin Pioneer Logging Exhibit
Located within the park on Highway 60, close to the eastern gate. Illustrates the history of logging in the area, an important Canadian technology. Open from May 3 to October 19 on weekends and holidays, and from June 3 to September 14 daily from 10:00 a.m. to 6:00 p.m.

M2. Atikokan Public Library and Centennial Museum
Contains displays relating to the development of the area, particularly in logging and iron mining. A special feature is a completely restored logging engine and train. Open Monday through Friday, 1:00 p.m. to 5:00 p.m.

M3. Base Borden (Simcoe County)
(a) Worthington Museum and Library
Traces the development of armoured fighting vehicles, an important part of recent military technology. Open Monday to Friday, 8:00 a.m. to 4:30 p.m.

(b) Royal Canadian Army Service Corps Museum
A collection of military equipment, dress, documents, and transport used by the corps in former years. Open daily from 9:00 a.m. to 4:00 p.m. (mornings only on Wednesday).

M4. Blind River — Timber Village Museum
A museum illustrating the lumbering industry and agriculture which pioneered the area, through models and full-scale replicas. Open Monday to Friday from 10:00 a.m. to 8:00 p.m., from June 1 to September 1.

M5. Brampton — County of Peel Museum and Art Gallery
The development of agriculture, transportation, and industry in Peel County. Open 9:00 a.m. to 5:00 p.m., Tuesday through Friday from May 25 to October 13, and weekend afternoons throughout the year except December. Visits can be made at other times by appointment.

M6. Brantford — The Bell Homestead
The former home of Alexander Graham Bell, furnished in the style of the period and displaying many of Bell's inventions. Open daily from 9:00 a.m. to 6:00 p.m., except Mondays.

M7. Brockville — Railway Tunnel
Canada's oldest railway tunnel, built 1854-60.

M8. Cobalt — Northern Ontario Mining Museum
Open daily in the afternoons, all day in the summer months.

M9. Coldwater — Grist Mill
A mill that has been in continuous operation since it was first built in 1833 for the local Indian community.

M10. Collingwood — Collingwood Museum
Located in a former railway station, this museum traces the history of the community and particularly the development of its ship-building industry. Open from May 24 to October 14 on weekends, and from June 15 to September 2 daily.

M11. Comber — Tilbury West Agricultural Museum
An exhibit illustrating the history and agricultural development of the area. Open daily from May 16 to October 15, except Wednesdays.

M12. Cornwall — United Counties Museum (In Wood House, 731 Second Street West)
A general historical museum that includes an early set of electrical equipment designed and installed by Thomas Edison for the nearby Stormont Mill. Open from May 1 to October 31. Inquire regarding hours.

M13. Corunna — Pilot House Museum
Located on Highway 40, five miles south of Sarnia. A restored pilot house that is now a museum illustrating life aboard the lake vessels. By appointment only.

M14. Elliot Lake — Mining and Nuclear Museum
Various exhibits illustrating pioneer mining techniques and methods of uranium mining. Open daily.

M15. Goderich — Huron County Pioneer Museum (104 North Street)
A museum that specializes in the history of motive power from the horse to the locomotive. Open daily from April 1 to October 31, and at other times by appointment.

M16. Guelph — Civic Museum
Exhibits illustrating local agricultural and industrial growth. Open from October to June, from 2:00 p.m. to 4:00 p.m. on Friday and Saturday, every afternoon from June to October.

M17. Kingston
(a) Old Fort Henry
The museum housed in this massive fortification contains a large collection of infantry, cavalry, artillery, and naval arms and equipment. Open daily from May 15 to September 15, from 9:30 a.m. to 5:00 p.m.

(b) The Royal Canadian Signals Museum
Located at Vimy Barracks, one mile east of Kingston on Highway 2. Houses exhibits relating to military communications. Open daily from 2:00 p.m. to 4:00 p.m., except Mondays and Saturdays.

(c) The Corps of Royal Canadian Electrical and Mechanical Engineers Museum

Located at McNaughton Barracks on Highway 2, one mile east of Kingston. Displays illustrate military history and technology. Open from 1:00 p.m. to 4:00 p.m. on Mondays, Tuesdays, Wednesdays, and Fridays.

M18. Madoc — O'Hara Sawmill
Located in the Moira River Conservation Area, three miles north of Highway 7, a short distance west of Madoc. The water-powered sawmill is usually operated on Sunday afternoons. The area is open daily from May 15 to September 30.

M19. Manotick — The Long Island Mill (Watson's Mill)
A restored water-powered flour and grist mill which began operation in 1860. Open from May 1 to September 30 daily from 9:00 a.m. to 5:00 p.m., and from 1:00 p.m. to 6:00 p.m. on weekends.

M20. Morrisburg — Upper Canada Village
Located on Highway 2, seven miles east of Morrisburg (one mile south of exit 120 off Highway 401). This living museum of over forty buildings portrays the evolution of life in Ontario from 1795 to 1860, including much of the relevant pioneer technology. Open from May 15 to October 15 daily, from 9:30 a.m. to 5:00 p.m.

M21. Niagara Falls
(a) The Antique Auto Museum
More than fifty vintage automobiles displayed in period settings. Open daily all year.

(b) Hydro Hall of Memory
Located in the Sir Adam Beck generating station on the Niagara Parkway, six miles north of the Falls. The history of the development and use of hydro-electric power in Ontario is traced. Open daily throughout the year.

M22. Oil Springs — Oil Museum of Canada
Located just off Highway 21 near Oil Springs (south of Petrolia). Situated near the site of the first commercial oil well in North America, this collection illustrates early methods of drilling. The equipment displayed includes full-size oil rigs. Open daily from May 18 to October 31, from 10:00 a.m. to 5:00 p.m., and weekends in November.

M23. Oshawa — Canadian Automotive Museum (99 Simcoe Street South)
Canada's contribution to the development of the automobile is illustrated through a collection of some forty vintage cars. Open daily 9:00 a.m. to 5:00 p.m. throughout the year.

M24. Ottawa
(a) National Museum of Natural Sciences (Metcalfe and McLeod Streets)

A natural history museum with sections on mammals, birds, paleontology, mineralogy, and geology. Open daily 9:00 a.m. to 5:00 p.m., from May to September, from 2:00 p.m. on Sundays.

(b) National Museum of Science and Technology

Located in southeast Ottawa at the corner of St. Laurent Blvd. and Russell Road. A large museum with major sections devoted to transportation, communications, the marine, manufacturing, meteorology, astronomy, and aviation as well as many other minor areas. Open daily all year from 9:00 a.m. to 9:00 p.m., closed Mondays from September to May.

(c) Canadian War Museum (330-350 Sussex Drive)

A large, well-displayed collection illustrating Canadian military history. Many examples of military technology are included. Open daily from 9:00 a.m. to 5:00 p.m., and from 12:00 noon on Sundays.

(d) National Aeronautical Collection (Rockcliffe Airport)
A collection of some forty aircraft illustrating the development of aviation in the Canadian Forces and in Canada generally. Open daily from 9:00 a.m. to 5:00 p.m., and Sundays from 2:00 p.m.

M25. Peterborough — Century Village and Lang Mill Museum

Located on Keene Road, three miles south of Highway 7, six miles east of Peterborough. A pioneer village of twelve restored buildings including a shingle mill and a blacksmith's shop that dates from the 1860's. The Lang Mill nearby is a restored nineteenth century flour and grist mill. Open from May 15 to September 2, from 1:00 p.m. to 7:00 p.m., except Mondays. Open weekends until October 14.

M26. Porcupine — Porcupine Mining Museum
An outdoor collection of items relating to the early history of mining in the district. Open daily from May 24 to September 15.

M27. Port Rowan — The Backus Mill and Agricultural Museum

Located in the Big Creek Conservation Area, three miles east of Highway 59, a mile north of Port Rowan. Agricultural implements, horse-drawn vehicles, and a flour mill built in 1798, the oldest remaining in Ontario, are displayed. Open weekends from May 17 to October 13.

M28. Rockton — Westfield Pioneer Village
Located on Highway 52, north of Highway 8. A reconstructed pioneer village of some fifteen buildings. Open from May 20 to October 31 on weekend afternoons.

M29. St. Catharines — Mountain Mills Museum (De Cew Falls)
A water-powered mill with all the original equipment used for grinding flour and feed. Open from May 18 to October 14. Inquire concerning hours.

continued

M30. Stratford — Minnie Thomson Memorial Museum (186 Vivian Street)
A collection of farm machinery and antique automobiles and tractors. Open from May 1 to November 1 daily, except Thursdays, from 1:00 p.m. to 8:00 p.m.

M31. Thunder Bay — Logging Museum (Centennial Park, Port Arthur)
Tools and equipment used in the logging industry are displayed, and a full-scale logging camp has been constructed in the bush nearby. Open from May 15 to October 15 daily from 12:00 noon to 6:00 p.m.

M32. Toronto
(a) **Ontario Science Centre** (770 Don Mills Road)
An outstanding group of more than 450 exhibits, many of them participational, illustrating both contemporary and historical aspects of science and technology. The Centre's main exhibit groups include: Molecular Science, Earth Science, Space Science, Engineering, Transportation, Basic Science and Perception, Communications and Computing, Life Sciences, Canadian Resources, and The North. Open daily throughout the year from 10:00 a.m. to 6:00 p.m.

(b) **Royal Ontario Museum** (Bloor Street West and Avenue Road)
Canada's leading museum. The exhibits describe the structure of the earth, its minerals, its animals (past and present), and human civilization from Babylon to early Canada. Open all year, Mondays to Saturdays from 10:00 a.m. to 5:00 p.m., Sundays from 1:00 p.m.

(c) **Black Creek Pioneer Village** (Jane Street and Steeles Avenue)
A restored village of more than twenty-two buildings with many live demonstrations illustrating the ordinary life and simple technology of rural Ontario of a hundred years ago. Open from April 28 to October 31 daily from 9:30 a.m. to 5:00 p.m.

(d) **Marine Museum of Upper Canada** (Canadian National Exhibition Grounds)
Housed in the former officers' quarters of Stanley Barracks, dating to 1840, the exhibits depict the exploration of central Canada and the development of shipping on the inland waterways of the Great Lakes and St. Lawrence. Open all year except during the CNE. Check for days and times.

(e) **Todmorden Mills Park** (67 Pottery Road)
A former brewery that is now a small historical museum and a former paper mill are preserved at this site. Open from May 19 to Thanksgiving from 1:00 p.m. to dusk, daily except Mondays.

M33. Wasaga Beach
(a) **Schoonertown**
A museum built on the site of a naval base which operated from 1815 to 1817 and which served as a depot where supplies from the Nine-Mile Portage and Willow Creek were trans-shipped to sailing vessels in the Upper Lakes. Open from May 15 to Labour Day daily from 10:00 a.m. to 5:00 p.m.

(b) **Museum of the Upper Lakes**
Built on an island formed around the hulk of the warship *H.M.S. Nancy*, which was burned and sunk during the War of 1812, the museum describes the marine history of the Upper Lakes. Open from May 17 to October 13 daily from 10:00 a.m. to 5:00 p.m.

M34. West Montrose — The Covered Bridge
The last covered bridge still in use in Ontario.

M35. Wyoming — Pioneer Power Museum
Located on Highway 7, about twelve miles east of Sarnia. A collection of engines, both steam and internal combustion, as well as antique vehicles. Open daily from 10:00 a.m. to 9:00 p.m.

M36. Detroit, Michigan
(a) **The Henry Ford Museum and Dearborn Village**
Located in the Dearborn district of Detroit. Contains an outstanding collection of road vehicles, railway engines and cars, aircraft, early machine tools, and engines of all sorts, including some of the earliest types of steam engines relocated from Britain and the Continent and illustrating all the major steps in the development of power. Open daily throughout the year. Inquire concerning times.

(b) **The Cranbrook Institute of Science** (550 Lone Pine Road, Bloomfield Hills, Michigan 48013)
Located in the grounds of the Cranbrook Institute in suburban Detroit. A small science museum that contains a number of participational exhibits illustrating basic physics. Check for opening days and hours.

Appendix B: Films

F1. A Is For Atom. General Electric, 22 mins., colour, 1953.
This film gives a simple yet comprehensive explanation of the principles of atomic energy. It indicates the possibilities of its peacetime applications in industry, medicine, agriculture, and science.

F2. Archimedes' Principle. Encyclopaedia Britannica, 6 mins., b/w, 1957.
This film recreates the events that led to the discovery of Archimedes' Principle and provides examples of the principle within the setting of a modern physics laboratory. By combining historical perspective and present-day practice, the film should encourage a feeling of interest in the subject and a better understanding of its experimental aspects.

F3. Darwin and the Theory of Natural Selection. Coronet, 14 mins., colour, 1968.
Through Darwin's observations of the coasts and islands of South America and experiments made in England, we are shown how he developed the "Theory of Natural Selection". The film contains many rare views of animal and plant life, photographed on the Galapagos Islands.

 **F4. Discovery of Insulin.** National Film Board, 18 mins., b/w, 1961.
The film re-enacts the critical year in Dr. Banting's life during which he made the important discovery of insulin. It dramatizes the obstacles he and Charles Best had to overcome and the final victory which gave new hope of life and health to many people.

F5. First Men Into Space. Encyclopaedia Britannica, 15 mins., colour, 1962.
This film illustrates the problems that attend man's survival in outer space. It shows how these problems were scientifically studied and solved and how the solutions were applied by engineers to the first space capsule. With the use of models, animation, and live photography, it shows the first American orbital space flight and how the solutions to the problems of man's survival in outer space have worked out in actual practice.

F6. Galileo's Laws. Encyclopaedia Britannica, 6 mins., b/w, 1953.
This film recreates events that led to Galileo's discovery of some of the fundamental laws pertaining to falling bodies. It provides demonstrations that verify Galileo's discoveries and uses special film techniques to make these demonstrations more comprehensible. By combining historical perspective and present-day practice, this film develops interest in the subject and a better understanding of its experimental aspects.

 **F7. Global Struggle for Food.** National Film Board, 28 mins., b/w, 1960.
Shortages in the world's food supply are threatening to become a disaster in view of swelling populations. To stave off this crisis, many new methods are being employed to increase crop production — water control, land redistribution, and various agricultural innovations.

F8. Health Heroes: The Battle Against Disease. Coronet, 11 mins., colour, 1959.

The contributions of five great men in the battle against disease are outlined within a historical framework. We see how Van Leeuwenhoek began the study of germs by improving the microscope; how Jenner developed the concept of vaccination; how Pasteur and Koch's study of germs threw new light on the causes of disease; and how Lister helped demonstrate the relationship between sanitation and health.

F9. Laws of Heredity. Encyclopaedia Britannica, 15 mins., colour, 1963.

The film demonstrates the mechanisms by which hereditary characteristics are transmitted from one generation to the next, and which make it possible to predict statistically the occurrence of inherited traits. The basic "Laws of Heredity" are formulated, along with the experimental evidence from which they were derived.

F10. Laws of Motion. Encyclopaedia Britannica, 14 mins., colour, 1952.

Newton's three laws of motion and the important events leading to their discovery are graphically explained. Experiments illustrate the theory and the application of laws, with demonstrations involving auto, train, airplane, and gun.



F11. Molecules for Burning. Imperial Oil, 28 mins., colour, 1969.

Scientific curiosity and technical creativity transform crude oil into fuel and a host of other products we could not do without.

F12. Natural Selection. Encyclopaedia Britannica, 16 mins., colour, 1963.

The role of natural selection in the evolution of living organisms is described, and an explanation of how natural selection operates by the action of selective agents upon variations within a species is given. Several demonstrations which substantiate and clarify the principle of natural selection are included in the film.

F13. Printing Through The Ages. Encyclopaedia Britannica, 22 mins., b/w, 1950.

This film traces the story of printing from ancient techniques to present-day processes. It depicts the gradual transition from printing pictures to printing letters as well as the evolution of modern type faces and improvements in the paper used for printing.



F14. Rise and Fall of the Great Lakes. National Film Board, 26 mins., colour, 1968.

A witty, sophisticated commentary on the effects of industrialization and pollution in the Great Lakes.

F15. Rutherford Atom. Physical Science Study Committee (PSSC), 40 mins., b/w, 1961.

Dr. Hulsizer uses a cloud chamber and gold foil in a simple alpha-particle scattering experiment to illustrate the historic Rutherford experiment which led to the nuclear model of the atom. Behavior of alpha-particles is clarified by use of large-scale models illustrating the nuclear atom and Coulomb scattering.

F16. Satellites: Stepping Stones to Space. Film Associates of California, 16 mins., colour, 1959.

This film explains what satellites are and why they are important to us. Through an examination of *Explorer 1*, the student is shown the instruments that satellites carry and what those instruments tell us about outer space.

F17. Stars and Star Systems. Encyclopaedia Britannica, 16 mins., b/w, 1966.

The film illustrates the work of astronomers with the reflecting and the radio telescope. It shows how astronomers rely on theoretical analysis as well as direct observation for answers to the mysteries of the universe.

F18. Story of Our Number System. Coronet, 11 mins., colour, 1958.

This film traces the historical development of numbers, including the counting systems of the Babylonian Empire, the Mayan civilization, and Rome; the development of calculation with the abacus; the need for a place holder, which became the zero; the probable development of our present symbols.

F19. The Hole. McGraw-Hill, 14 mins., colour, 1962.

In this prize-winning animated cartoon, two construction workers digging a hole reveal the psychology of the ordinary man living in a world menaced by nuclear oblivion.

F20. This Is Marshall McLuhan. McGraw-Hill, 53 mins., colour, 1968.

A portrait of the Canadian philosopher whose insights have shown us how profoundly our logic and perceptions are conditioned by the media through which we communicate.

F21. Why Man Creates. International Telefilm Enterprises, 30 mins., colour, 1969.

An exploration of man's creative urge, the impulse behind not only artistic creation, but great technological and scientific achievements.

F22. The Weird World of Robots. McGraw-Hill, 26 mins., colour, 1969.

This film provides visual evidence of the kinds of performance that may be obtained from robots now and in the future, and stimulates creative thinking about the potential achievements of the more extensive partnership between men and machines in prospect before the year 2000 A.D.

F23. Inherit The Wind. United Artists, 127 mins. Feature film, rental only.

An excellent film treatment of the famous trial in which Scopes, a young high school biology teacher, was charged with having contravened the State of Tennessee's anti-evolution law by teaching the subject to his classes.

F24. 2001: A Space Odyssey. MGM, 160 mins. Feature film, rental only.

A look into the logical extension of the new space technology, which reveals the essence of man's technology.

F25. On The Beach. United Artists, 133 mins. Feature film, rental only.

Based on the novel by Nevil Shute, this film deals with the aftermath of a nuclear war.

F26. The Grapes of Wrath. 20th Century-Fox, 115 mins. Feature film, rental only.

A powerful film based on John Steinbeck's novel which deals with the cost in human terms of a changing agricultural technology.

Distributors of Films

Arbor Scientific Inc.

Agents for: PSSC

P.O. Box 113, Port Credit, Ontario.

Canadian General Electric

214 King Street West, Toronto, Ontario.

Coronet Educational Films

Unit 6, 2 Thorncliffe Park Drive, Toronto 17.

Encyclopaedia Britannica

151 Bloor St. West, Toronto 5, Ont.

Holt, Rinehart & Winston

Agents for: Bailey-Film Associates

55 Horner Avenue, Toronto 18, Ontario.

Imperial Oil Ltd.

1 Duncan Mill Road, Don Mills, Ont.

International Tele-Film Enterprises

Agents for: Pyramid

221 Victoria Street, Toronto, Ont.

Metro-Goldwyn-Mayer Pictures of Canada

696 Yonge Street, Toronto, Ont.

McGraw-Hill Co. Canada Ltd.

330 Progress Avenue, Scarborough, Ont.

National Film Board

1 Lombard Street, Toronto, Ont.

Twentieth Century Fox Corp. Ltd.

110 Bond Street, Toronto, Ont.

United Artists Corp. Ltd.

387 Bloor St. East, Toronto, Ont.

Appendix C: Printed Material

Part 1 — Bibliography

The bibliography that follows contains almost three hundred annotated references to books in the fields of interest to those preparing courses in Man, Science, and Technology. It is only a very small and arbitrary selection of the material available, but it will give some idea of the richness and variety of print resources.

The bibliography represents an extension of the list of possible topics given earlier on pages 8 to 13. Virtually every book suggests a worthwhile topic that can become a vehicle in developing the objectives of a course. The books vary greatly in depth from picture books for children to scholarly accounts written by professionals in the field. The teacher must therefore use discretion in choosing amongst them and attempt as much as possible to relate the reference material used to the interests and abilities of his students. Many of the books are primarily for teacher reference or the use of advanced individual students.

Section I Reprints or Collections of Original Sources

1. Aelian. *On Animals*. (“De natura animalium”) Translated by A. F. Scholfield. Loeb Greek Series. London: William Heinemann Ltd., 1959.
Parallel Greek and English texts of one of the world’s earliest biological commentaries.
2. Aristotle. *Physics*. Edited by W. D. Ross. London: Oxford University Press, 1936.
One of the great treatises of the father of systematic science.
3. Bacon, Francis. *The Advancement of Learning*. Edited by G. W. Kitchin. Everyman’s Library. London: J. M. Dent & Sons Ltd., 1965.
Bacon’s famous text in which the “scientific method” based on experiment and observation is first formally put forward as a method of “advancing” learning.
4. Boyle, Robert. *The Sceptical Chemist*. Introduction by E. A. Moelwyn-Hughes. Everyman’s Library. London: J. M. Dent & Sons Ltd., 1964.
Robert Boyle’s account of his scientific work and views, first published in 1661, in which he is “sceptical” of results that cannot be put to experimental test.
5. Curie, Marie. *Radioactive Substances*. New York: Philosophical Library, 1961.
Marie Curie’s thesis presented to the Faculty of Science of the Sorbonne in Paris. This investigation of radioactive substances led to the Nobel Prize in 1911.
6. Darwin, Charles. *The Expression of the Emotions in Man and Animals*. Chicago: University of Chicago Press, 1965.
A reprint of a classical work by Darwin.
7. Darwin, Charles. *On the Origin of Species*. London: C. A. Watts Co. Ltd., 1950.
A full reprint of the first edition, with an introduction by C. D. Darlington.
8. Darwin, Charles. *On the Origin of Species*. 6th ed. World’s Classics Series. London: Oxford University Press, 1951.
A reprint of the sixth edition with a preface by Sir Gavin de Beer in which he gives reasons for selection of the sixth in preference to earlier editions.
9. Descartes, R. *A Discourse on Method*. Everyman’s Library. London: J. M. Dent & Sons Ltd., 1949.
A classic work by the famous philosopher whose work has profoundly affected scientific thought.
10. Euclid. *The Elements*. Edited by Isaac Todhunter. Everyman’s Library. London: J. M. Dent & Sons Ltd., 1961.
This famous text by the ancient Greek

mathematician and founder of systematic geometry formalized our ideas of space for almost 2000 years.

11. Faraday, Michael. *Experimental Researches in Electricity*. New York: Dover Publications Inc., 1966.
Faraday’s own account of his research — still considered a model of scientific method.
12. Gabriel, Mordecai L., and Fogel, Seymour, eds. *Great Experiments in Biology*. Englewood Cliffs, N. J.: Prentice-Hall Inc., 1955.
A volume of excerpts from the biological literature tracing the major steps in the development of a number of important biological concepts. Each topic includes a useful chronology of major developments and each excerpt is placed in context by a brief introduction.
13. Galen. *On the Usefulness of the Parts of the Body*. Edited by Margaret T. May. 2 vols. New York: Cornell University Press, 1968.
The most important works of the second century A.D. Greek physician whose knowledge and theory dominated medicine until the beginning of the modern period.
14. Galileo, Galilei. *Dialogue Concerning the Two Chief World Systems: Ptolemaic and Copernican*. 2nd ed. Translated by Stillman Drake. Berkeley, Calif.: University of California Press, 1967.
Galileo analyses the two rival theories of the universe in his time and comes out in favour of the earth-centred model of Copernicus. In making this decision, he placed himself in conflict with the Church.
15. Huxley, Thomas H. *Man’s Place in Nature*. Ann Arbor, Michigan: University of Michigan Press, 1959.
Huxley’s classical study of the comparative anatomy of man and the larger apes, which settled once and for all the question of man’s kinship with the animal world.
16. Kirwan, R. *An Essay on Phlogiston and the Constitution of Acids*. (Reproduction of 2nd ed., 1789.) Library of Science Classics. London: Frank Cass & Co. Ltd., 1968.
A reprint of a classical contribution to the early development of chemistry.
17. Knight, D. M., ed. *Classical Scientific Papers: Chemistry*. London: Mills & Boon Ltd., 1968.
A collection of “classical” papers in chemistry, which were landmarks in their day, opening the way to new concepts and discoveries.
18. Lamarck, J. B., *Zoological Philosophy*. Translated by Elliot. Kingston-upon-Thames, Surrey, England: Hafner Publishing Co., 1914.
Lamarck, the French biologist, was the first to develop a logical theory of evolution.

19. Leavitt, Thomas W., *The Hollingsworth Letters: Technical Change in the Textile Industry*. Cambridge, Mass.: The M.I.T. Press, 1969.

A set of letters written by an English family displaced from the British textile trade by technological changes and who emigrated to America in the 1820s and there tried to set up a new textile plant. Illustrates excellently the effect of technological innovations on human lives.

20. Locke, John. *An Essay Concerning Human Understanding*. Edited by A. S. Pringle-Pattison. Abridged Edition. London: Oxford University Press, 1924.

Another philosopher whose work had great influence in the development of scientific thought.

21. Lucretius. *The Nature of the Universe*. Translated by Ronald Latham. Classics Series. Harmondsworth, Middlesex, England: Penguin Books, 1951.

22. Lucretius. *Of the Nature of Things*. Translated by W. E. Leonard. New York: E. P. Dutton & Co. Inc., 1957.

This and the preceding text summarize in poetical form the main ideas of “classical” science.

23. Malthus, Thomas R. *Population: The First Essay*. Ann Arbor, Michigan: University of Michigan Press, 1959.

A reprint of Malthus’s famous essay on population which gave Darwin the clue to the idea of evolution by natural selection.

24. Mendel, G. *Experiments in Plant Hybridisations*. Edinburgh, Oliver & Boyd Ltd., 1965.

A reprint of Mendel’s classical paper which laid the foundation of modern genetics.

25. Moulton, Forest Ray, and Schifferes, Justus J., eds. *The Autobiography of Science*. London: John Murray Ltd., 1963.

An anthology of the world’s great scientific triumphs in the original words of the men and women who achieved them.

26. Newton, Sir Isaac. *The Mathematical Principles of Natural Philosophy*.

Translated by Andrew Motte. 2 Vols. London: Dawsons of Pall Mall. (Vol. 1: The Motion of Bodies, 1968; Vol. 2: The System of the World, 1968).

Newton’s famous *Principia* in which he sets out most of his major scientific deductions.

27. Pliny the Elder. *Natural History*. 10 Vols. Loeb Classical Library. Cambridge, Mass.: Harvard University Press, 1940-1963.

A work that summarizes the classical knowledge of the natural world.

28. Shamos, Morris H. *Great Experiments in Physics*. New York: Holt, Rinehart & Winston, 1959.

Similar in format to item 12.

29. Steno, Nicolaus. *The Prodromus of a Dissertation Concerning a Solid Body Enclosed by Process of Nature within a Solid*. Translated by J. G. Winter.

Contribution to the History of Geology Series. Kingston-upon-Thames, Surrey, England: Hafner Publishing Co., 1968.

A newly edited English translation of one of the great classics of geology, the *Prodromus* of the Danish geological pioneer Niels Steenson (Steno), in which new and sound conclusions were arrived at concerning stratigraphy and the origin of fossils.

30. Wright, Stephen, ed. *Classical Scientific Papers: Physics*. London: Mills & Boon Ltd., 1964.

A collection of classical papers which are commonly referred to in histories of physics.

Section II Biographies or Collections of Biographies

31. Andrade, Edward N. *Sir Isaac Newton: His Life and Work*. Anchor Books. Garden City, N.Y.: Doubleday & Co. Inc., 1958.

Newton’s originality and the importance of his contributions to mathematics, physics, and astronomy are clearly outlined.

32. Armitage, A. *Edmond Halley*. British Men of Science Series. London: Thomas Nelson & Sons Ltd., 1966.

A biography of the famous astronomer who discovered the comet that bears his name.

33. Armitage, Angus. *William Herschel*. British Men of Science Series, London: Thomas Nelson & Sons Ltd., 1962.

This account of the life and work of the astronomer Sir William Herschel establishes the historical context of his work. It indicates some of the problems he dealt with and shows how his work complements modern astronomy.

34. Asimov, Isaac. *Asimov’s Biographical Encyclopedia of Science and Technology*. Garden City, N.Y.: Doubleday & Co. Inc., 1964.

A collection of encyclopedia-type biographies of famous scientists and engineers.

35. Bailey, Edward. *Charles Lyell*. British Men of Science Series. London: Thomas Nelson & Sons Ltd., 1962.

Describes the work of Charles Lyell, one of the founders of modern geology. His chief works are analysed and their importance assessed. His books were among the germinal influences on Charles Darwin.

36. Beeby-Thompson, A. *Oil Pioneer*. London: Sidgwick & Jackson, 1961.

Autobiography of a great consultant engineer whose sixty years’ experience of petroleum exploration and oil field development began in the Baku oil fields of Russia in 1898.

37. Biquard, Pierre. *Frederic Joliot-Curie*. Profiles in Science Series. London: Souvenir Press Ltd., 1965.

An account of the life and work of the famous French atomic physicist.

38. Boucher, C. T. G. *John Rennie, 1761-1821: The Life and Work of a Great Engineer*. Manchester, England: Manchester University Press, 1963.

One of the great civil engineers of his day John Rennie was responsible for the construction of the great Lancaster Canal which he carried over the River Lune by means of a novel form of aqueduct.

continued

39. Brecht, Bertold. *The Life of Galileo*. New ed. Translated by D. I. Vesey. Modern Plays Series. London: Methuen & Co. Ltd., 1963.

A life of Galileo by the great modern German dramatist Bertold Brecht.

40. Brooks, E. St. John. *Sir Hans Sloane: The Great Collector and His Circle*.

Portland: Old Oregon Book Store, 1954.

A biography of a late seventeenth-century scientist.

41. Cameron, Hector C. *Sir Joseph Banks: The Autocrat of the Philosophers*. San Francisco: Tri-Ocean Inc., 1952.

A balanced and spirited portrait of Sir Joseph Banks (1744-1820), who was President of the Royal Society in a very fertile period. It includes a wide selection of extracts from contemporary documents and introduces many of the explorers, scientists, and social leaders of the time.

42. Caspar, Max. *Kepler, 1571-1630*.

New York: Abelard-Schuman Ltd., 1960.

A biography of the famous astronomer.

43. Crowther, J. G. *British Scientists of the Twentieth Century*. London: Routledge & Kegan Paul, 1952.

A substantial and well-documented work which includes studies of J. J. Thomson, Lord Rutherford, Sir James Jeans, Sir Arthur Eddington, Sir Frederick G. Hopkins, and W. Bateson. Their work, personalities, and place in history and society are assessed and examined. *British Scientists of the Nineteenth Century* (Kegan Paul, 1935), by the same author, is unfortunately out of print. It includes similar studies of Humphrey Davy, Michael Faraday, James Prescott Joule, W. Thomson, and James C. Maxwell.

44. Crowther, J. G. *Founders of British Science*. London: Cresset Press, 1960.

Profiles of John Wilkins, Robert Boyle, John Ray, Christopher Wren, Robert Hooke, and Isaac Newton.

45. Crowther, J. G. *Francis Bacon: The First Statesman of Science*. London: Cresset Press, 1960.

A substantial biography of a man whom the author describes as "the first example of the new kind of statesman required for organising society in which scientific activity and human life are one". The book is in two parts, the first dealing with Bacon's scientific theories, and the second with the events of his life and his part in politics.

46. Crowther, J. G. *Scientists of the Industrial Revolution*. London: Cresset Press, 1962.

Studies of James Watt, Henry Cavendish, Joseph Priestley, and Joseph Black.

47. Crowther, J. G. *Six Great Inventors: Watt, Stephenson, Edison, Marconi, The Wright Brothers, Whittle*. London: Hamish Hamilton Ltd., 1954.

A volume of brief biographies, written specifically for students of secondary school age.

48. Cuny, Hilaire. *Louis Pasteur: The Man and His Theories*. Translated by P. Evans. Profiles in Science Series. London: Souvenir Press Ltd., 1965.

A description of the life and work of Louis Pasteur.

49. Curie, Eve. *Madame Curie*. New ed. London: William Heinemann Ltd., 1962.

The standard and exciting biography of the pioneer of radium research, written by her daughter.

50. Darwin, Charles R. *Autobiography*. Edited by Francis Darwin. (Including notes and letters depicting the growth of the *Origin of Species*, and an introductory essay "The Meaning of Darwin" by George Gaylord Simpson.) Collier Books. New York: Macmillan Co., 1961.

Darwin's life and the genesis of his theory of natural selection are traced in his own words.

51. Darwin, Francis. *The Life and Letters of Charles Darwin*. 3 Vols. New York: Johnson Reprint Corp., 1969.

The standard work on Darwin's life and the principal printed collection of his letters, edited by his grandson.

52. De Beer, G. *Charles Darwin*. British Men of Science Series. London: Thomas Nelson & Sons Ltd., 1963.

One of the best biographies of Darwin, an authentic account not only of his life but of the evolution of his scientific thought.

53. De Latil, Pierre. *Enrico Fermi: The Man and His Theories*. New York: Paul S. Eriksson Inc., 1966.

A combined biography and explanation of the work of the famous Italian nuclear physicist.

54. Dubois, Rene. *Pasteur and Modern Science*. Anchor Books. New York: Doubleday & Co. Inc., 1960.

A biographical treatment of Pasteur and his place in modern science.

55. Espinasse, Margaret. *Robert Hooke*. London: Heinemann Educational Books Ltd., 1956.

This short biography is a good introduction to a remarkable figure. Hooke was an architect, surveyor, and inventor, and the first Curator of Experiments to the Royal Society in 1662. His book, *Micrographia*, recording important microscopic observations, is prefaced by an account of the state and aims of contemporary science.

56. Farber, E. *Nobel Prize Winners in Chemistry, 1901-1961*. London: Abelard-Schuman Ltd., 1964.

Brief biographical accounts of the famous chemists who have won the Nobel Prize and outlines of the work for which it was awarded.

57. George, W. *Biologist Philosopher: A Study of the Life and Writing of Alfred Russel Wallace*. London: Abelard-Schuman Ltd., 1964.

A combined biography and description of the biological work of the man who, independently of Darwin, arrived at a theory of evolution by natural selection as a result of his observations of the natural history of the Malay archipelago.

58. Granit, R. *Charles Scott Sherrington*. British men of Science Series. London: Thomas Nelson & Sons Ltd., 1966.

A biography of the great neurophysiologist.

59. Gregor, Arthur S. *Charles Darwin*. New York: E. P. Dutton & Co. Inc., 1966.

A well-written book that deals with Darwin's career from a biographical point of view. Particular attention is paid to the way in which Darwin's ideas came to be formulated in the concept of evolution. A glossary and a list of further readings are included.

60. Grenet, Abbé Paul. *Teilhard de Chardin*. Translated by R. A. Rudorff. Profiles in Science Series. London: Souvenir Press Ltd., 1965.

A combined biography and exposition of the theories of the French biologist and mystic.

61. Hahn, Otto. *Otto Hahn: A Scientific Autobiography*. Edited by W. Ley. Introduction by Glenn T. Seaborg. New York: Charles Scribner's Sons, 1966.

Otto Hahn, one of the fathers of radiochemistry and the discoverer in 1938 of the splitting of the atom, recounts his life, particularly his scientific activities.

62. Hart, Ivor B. *Leonardo Da Vinci*. London: Weidenfeld & Nicolson Educational Ltd. (now Rupert Hart-Davis Educational Publications), 1964.

A substantial biographical study of Leonardo's scientific contribution, set against the background of the culture and politics of his time.

63. Hoskin, Michael A. *William Herschell*. New York: W. W. Norton & Co. Inc., 1964.

An account of Herschell's life (1738-1822) and of his principal astronomical investigations.

64. Howard, Arthur V., ed. *Chamber's Dictionary of Scientists*. New ed. London: W. & R. Chambers Ltd., 1964.

Some 1300 biographical entries of men who have shaped the course of science.

65. Huxley, T. H. *The Essence of T. H. Huxley*. Edited by C. Bibby. London: Macmillan & Co. Ltd., 1968.

Excerpts from the writings of Thomas Huxley designed to give a composite picture of this famous Victorian, the great protagonist of Darwin's theories and a pioneer in educational reform.

66. Josephson, Matthew. *Edison*. New York: McGraw-Hill Book Co., 1963.

Edison was closely and keenly concerned with the commercial development of his inventions, and this detailed biography deals fully with his activities in the field of industrial technology as well as in the laboratory.

67. Keele, K. D. *William Harvey, the Man, the Physician, the Scientist*. British Men of Science Series. London: Thomas Nelson & Sons Ltd., 1965.

A biography of the discoverer of the circulation of the blood.

68. Kendall, James. *Humphrey Davy, "Pilot" of Penzance*. London: Faber & Faber Ltd., 1954.

The life of a great chemist briefly told.

69. Kendall, James. *Michael Faraday, Man of Simplicity*. London: Faber & Faber Ltd., 1955.

A delightful portrait of Faraday, written for the general reader.

70. Lenard, Philip. *Great Men of Science: A History of Scientific Progress from Pythagoras to the Twentieth Century*. Translated by Hatfield from 2nd German ed. London: G. Bell & Sons Ltd., 1933.

Brilliant studies of famous scientists of many nationalities, from Pythagoras to Crookes, and their contributions to scientific thought. Dr. Lenard was Professor of Physics and Director of the Radiological Institute at Heidelberg University, and a Nobel Laureate.

71. Mann, A. L., and Vivian, C. *Famous Biologists*. London: Museum Press, 1963.

This account of pioneers in biology includes simple key experiments to help the reader appreciate the problems they solved.

72. Maurois, André. *The Life of Alexander Fleming: Discoverer of Penicillin*. Translated by Gerard M. Hopkins. New York: E. P. Dutton & Co. Inc., 1959.

A standard biography of the great microbiologist.

73. McKie, Douglas. *Antoine Lavoisier: Scientist, Economist, Social Reformer*. Collier Books. New York: Macmillan Co., 1962.

A biography of the great French chemist who died at the guillotine in 1794.

74. Morgan, Bryan. *Men and Discoveries in Chemistry*. London: John Murray Ltd., 1962.

Traces the development of chemistry from its earliest beginnings to the twentieth century through the lives and work of some of the great chemists.

75. Morgan, Bryan. *Men and Discoveries in Electricity*. London: John Murray Ltd., 1952.

No scientific background is required for this historical account of the major discoveries in electricity, seen through the eyes of the men concerned.

76. Pilkington, Roger. *Robert Boyle: Father of Chemistry*. London: John Murray Ltd., 1959.

A short general biography of the seventeenth century scientist and aristocrat.

77. Pringle, Patrick. *Great Discoverers in Modern Science*. Ulverscroft Large Print Series. New ed. Glenfield, Leicester, England: F. A. Thorpe Publishing Ltd., 1965.

Brief sketches of the working lives of twelve men who have contributed to modern science, including Fleming, Einstein, Whittle, Oppenheimer, and Watson Watt. Primarily intended for young readers.

78. Ricardo, Harry R. *Memories and Machines*. London: Constable & Co. Ltd., 1968.

The memoirs of one of the pioneers in the development of the internal combustion engine.

79. Riedman, Sarah R. *Men and Women Behind the Atom*. London: Abelard-Schuman Ltd., 1958.

Biographical sketches of some of the scientists associated with the study of the atom and its fission.

80. Rolt, L. T. C. *Great Engineers*. London: G. Bell & Sons Ltd., 1966.

Biographical outlines of English engineers who contributed significantly to the development of engineering science in the nineteenth century. Such figures as Darby, Newcomen, Jessop, Murray, Maudslay, Joseph Locke, Fowler, Baker, Crompton, and Lanchester are dealt with, beginning with the iron master and going through to automobiles and aeronautics.

81. Rolt, L. T. C. *Isambard Kingdom Brunel*. Harlow, Essex, England: Longman Group Ltd., 1957.

A full-scale biography of a great engineer and dynamic personality of the mid-nineteenth century. Brunel's activities were mainly related to railways and shipbuilding. He engineered the Thames Tunnel and the building of the Great Western Railway with its important viaducts, and was a pioneer in transatlantic steamship construction.

82. Rowland, J. *Ernest Rutherford, Master of the Atom*. London: Arthur Barker Ltd., 1964.

A biography of the greatest of modern scientists, the discoverer of the atomic nucleus and the moving spirit behind an entire generation of eminent followers, from Otto Hahn to Niels Bohr.

83. Smiles, Samuel. *Lives of the Engineers: Selections from Samuel Smiles*. Edited by T. P. Hughes. Cambridge, Mass.: The M.I.T. Press, 1966.

A collection of short biographies of some of the great engineers.

84. Travers, Morris W. *A Life of Sir William Ramsay*. London: Edward Arnold & Co., 1956.

An excellent scientific biography of an outstanding research worker, with chapters on Ramsay's role in the discovery of argon, neon, krypton, and xenon, and in the chemistry of radium.

85. Von Karman, Theodore, and Edson, Lee. *The Wind and Beyond: Theodore Von Karman, Pioneer in Aviation and Pathfinder in Space*. Boston: Little, Brown & Co., 1967.

The biography of a pioneer aeronautical engineer.

86. Wiener, Norbert. *I am a Mathematician*. London: Victor Gollancz Ltd., 1956.

The autobiography of a famous mathematician and a pioneer in the science of cybernetics. No special mathematical knowledge is required to appreciate this book.

87. Williams, Harley. *Great Biologists*. London: G. Bell & Sons Ltd., 1961.

A simply written book providing background information on such biologists as Aristotle, Charles Darwin, Alfred Russel Wallace and Thomas Hunt Morgan.

88. Williams, L. Pearce. *Michael Faraday*. London: Chapman & Hall, 1965.

A biography of one of the world's greatest experimental scientists.

continued

Section III General Histories of Science and Technology and Their Divisions

89. Anthony, H. D. *Science and Its Background*. 4th ed. London: Macmillan & Co. Ltd., 1961.

An outline of the development of science as it relates to the history of world affairs, from prehistoric times to the middle of the twentieth century. Most of the chapters centre around individual scientists. The final chapters discuss post-war technology and the pursuit of science for its own sake.

90. Armytage, W. H. G. *A Social History of Engineering*. 2nd ed. Technology Today and Tomorrow Series. London: Faber & Faber Ltd., 1966.

A concise survey from prehistory to 1960. The author states his aims: "... to chart technological developments with special reference to Britain, to indicate how they have affected and been affected by social life ... and to offer some clues as to the origins of innovations and institutions." Useful bibliographies are appended.

91. Asimov, Isaac. *A Short History of Biology*. London: Thomas Nelson & Sons Ltd., 1965.

One of the best short histories of the subject.

92. Bernal, J. D. *Science in History*. 4th ed. London: C. A. Watts Co. Ltd., 1969.

A review of the influence of science on social and economic history and the development of civilization, from earliest records to the present day. Approximately half this substantial work is devoted to twentieth-century developments. Social as well as physical and biological sciences are discussed. An extensive bibliography is provided.

93. Booker, P. J. *A History of Engineering Drawing*. London: Chatto & Windus Ltd., 1963.

A history of engineering drawing from the earliest days to the present. The author has made use of a wide selection of quotations from other important books which are readily attainable. This book will likely be of interest to students who have an interest and background in mechanical or architectural drafting.

94. Bronowski, J. *The Common Sense of Science*. London: Heinemann Educational Books Ltd., 1951. Paperback by Penguin Books, 1968.

A concise account of the development of scientific ways of thought and method since the seventeenth century.

95. Burstall, Aubrey F. *A History of Mechanical Engineering*. New ed. Technology Today and Tomorrow Series. London: Faber & Faber Ltd., 1965.

A record of the machines, mechanical inventions and ideas from ancient to modern times which appear to the author to have been most significant for the art and science of mechanical engineering.



96. Butterfield, Herbert. *The Origins of Modern Science, 1300-1800*. Toronto: Clarke, Irwin & Co. Ltd., 1968.

An account of the development of modern science from 1300 to 1800. The historian Butterfield attempts to trace the relationship of historical ideas to human events during this period. This book will be of interest to teachers and students who are at a mature reading level.

97. Crowther, J. G. *A Short History of Science*. General Studies Series. London: Methuen & Co. Ltd., 1969.

A treatment of science as one of the major responses of man to his experience of living. It is intended to show science students who may be preoccupied with the manipulation of instruments and symbols the relationship of their scientific interests to the rest of life, and to help students see that science has developed from man's effort to improve his material and spiritual condition and that it is an essential part of his humanity. Various aspects of science are dealt with; such things as navigation, astronomy, the invention of the steam engine, new sources of power, chemistry, and industry all provide useful insights for the student of the history of science.

98. Dampier, William C. *A History of Science and Its Relations with Philosophy and Religions*. 4th ed. London: Cambridge University Press, 1948.

A scholarly work, first published in 1929 and brought up to date in 1948.

99. Daumas, Maurice, ed. *A History of Technology and Invention: Progress Through the Ages*. Translated by E. B. Hennessy. New York: Crown Publishers Inc., 1969. (Vol. I — The Origins of Technological Civilization; Vol. II — The First Stages of Mechanization).

A large-scale encyclopedic work which covers every aspect of the subject from primitive societies to the sixteenth century in all parts of the world by means of chapters authored by specialists in each field. The editor is curator of the Musée des Arts et Métiers in Paris.

100. Derry, T. K., and Williams, Trevor I. *A Short History of Technology from Earliest Times to A.D. 1900*. London: Oxford University Press, 1960.

Although it owes much to Oxford's five-volume *History of Technology* (edited by Sir Charles Singer and others), this is nevertheless an entirely separate work, planned for a wider readership. It is presented in two parts: Part I covers developments up to the middle of the

eighteenth century; Part II, the Industrial Revolution to 1900. Each has a general historical introduction followed by studies of different branches of technology.

101. Dreyer, John L. *A History of Astronomy from Thales to Kepler*. New York: Dover Publications Inc., 1953. A short history of astronomy.

102. Eco, Umberto, and Zorzoli, G. B. *A Picture History of Inventions: From Plough to Polaris*. Translated by Anthony Lawrence. New York: Macmillan Co., 1963.

An encyclopedia tracing man's history from the Stone Age cave-dweller's attempts to make tools to the fantastic technological successes of the twentieth century in the fields of atomic science and space flight.

103. Einstein, Albert, and Infeld, Leopold. *The Evolution of Physics*. New York: Simon & Schuster Inc., 1938.

A history of the evolution of basic concepts in physics, particularly through the revolution the two authors were so intimately connected with.

104. Findlay, A. *A Hundred Years of Chemistry*. 3rd ed. Edited by T. Williams. London: Methuen & Co. Ltd., 1965.

A history of some of the principal themes in chemistry over the last one hundred years.

105. Forbes, R. J. *Man the Maker: A History of Technology and Engineering*. 2nd ed. Life of Science Library Series. London: Constable & Co. Ltd., 1959.

An outline history of technical inventions from the Old Stone Age to 1930 — power resources, transport and communication, metallurgy, textiles, glass, chemical technology, and some aspects of civil engineering.

106. Forbes, R. J., and Dyksterhuis, E. J. *A History of Science and Technology*. Pelican Series. Harmondsworth, Middlesex, England: Penguin Books, 1963. (Vol. I — Ancient Times to the 17th Century; Vol. II — The 18th and 19th Centuries)

An outline of the scientific knowledge and "know-how" that western civilization has acquired down the centuries.

107. Hall, A. Rupert. *From Galileo to Newton, 1630-1720*. The Rise of Modern Science Series. London: William Collins Sons & Co. Ltd., 1963.

An account of the triumph of reason in science and of the men who achieved it.

108. Hall, A. Rupert. *The Scientific Revolution, 1500-1800: The Formation of the Modern Scientific Attitude*. 2nd ed. Harlow, Essex, England: Longman Group Ltd., 1962.

A study of the development of scientific ideas and methods. The author, Lecturer in History at the University of Cambridge, defines the state of knowledge at the end of the Middle Ages and traces subsequent advances and changes of outlook up to the end of the seventeenth century.

109. Hughes, Arthur. *A History of Cytology*. London: Abelard-Schuman Ltd., 1959.

Traces the study and development of research on the behaviour of the living cell from its origin in the seventeenth century to its modern relationships to other fields of biology.

110. Hull, L. W. H. *History and Philosophy of Science: An Introduction*. Harlow, Essex, England: Longman Group Ltd., 1965.

This publication bridges the gap between science and the humanities. The growth of scientific ideas, with their influence and dependence on concurrent historical and philosophical developments, is traced from Greek to modern times.

111. Ihde, Aaron J. *The Development of Modern Chemistry*. Scranton, Pa.: Harper & Row, 1964.

A history of the development of chemistry in modern times.

112. Klemm, F. *A History of Western Technology*. Translated by D. W. Singer. London: George Allen & Unwin Ltd., 1959. The chronological development of western technology beginning with classical antiquity and continuing through to the Industrial Revolution.

113. Ley, Willy. *Watchers of the Skies: An Informal History of Astronomy from Babylon to the Space Age*. New York: The Viking Press Inc., 1963.

The author begins with the story of the Chaldeans in the year 1000 B.C. and continues chronologically to the Napoleonic era. As the pattern of knowledge becomes more complex in the nineteenth century, the history of each planet is dealt with separately. The book concludes with a general survey of our galaxy.

114. Lindsay, R. B. *The Nature of Physics: A Physicist's Views on the History and Philosophy of His Science*. Providence, Rhode Island: Brown University Press, 1968.

A very good book that uses a combination of the history and philosophy of the subject to probe deeply into the foundations of physics.

115. Long, E. R. *A History of Pathology*. Rev. ed. New York: Dover Publications Inc., 1965.

A history of our understanding of disease and the conditions it produces.

116. McKenzie, A. E. E. *The Major Achievements of Science*. 2 Vols. London: Cambridge University Press, 1960.

A history of the development of the main generalizations of science, their philosophical implications, and their influence on western thought. Brief biographical accounts of outstanding scientists are included.

Volume 2 contains ninety-one extracts from the *Literature of Science* to illustrate Mr. McKenzie's themes. These extracts are comprehensible to the general reader and have been chosen for their liveliness and human interest as well as for their scientific value. Each extract has a brief note describing its origin and importance.

117. Mumford, Lewis. *Technics and Civilization*. London: Routledge & Kegan Paul, 1934.

A history of the development of machinery and its effect on mankind.

118. Pannekoek, A. *A History of Astronomy*. London: George Allen & Unwin Ltd., 1961.

A scholarly work translated from the Dutch.

119. Partington, J. R. *A Short History of Chemistry*. 3rd ed. London: Macmillan & Co. Ltd., 1957.

A lucid and authoritative survey of the history of chemistry with reference to the most important sources.

120. Pledge, H. T. *Science Since 1500*. 2nd ed. Science Museum. London: Her Majesty's Stationery Office.

A short general history of mathematics, physics, chemistry, and biology since 1500.

121. Price, Derek J. *Science Since Babylon*. New Haven, Conn.: Yale University Press, 1961.

A work based on five public lectures in which the author "strove to cover the gamut of the historical range from the Babylonians to the near future, bringing in as many fields of application as possible."

122. Read, John. *Through Alchemy to Chemistry*. London: G. Bell & Sons Ltd., 1961.

An introduction to the history of chemistry. Read's book shows how "modern" chemistry evolved from the craft of the ancient alchemists.

123. Reason, H. A. *The Road to Modern Science*. Rev. ed. London: G. Bell & Sons Ltd., 1959.

A short history written for older boys and girls but suitable also for adult readers. This third edition has been revised and brought up to date to include recent advances.

124. Ronan, C. A. *The Ages of Science*. London: George G. Harrap & Co. Ltd., 1966.

A very detailed book with some helpful illustrations, dealing with anatomy, astronomy, biology, medicine, chemistry, physics, mathematics, and the beginnings of evolution. Useful as a background book for general scientific ideas.

125. Ronan, C. A. *Their Majesties' Astronomers: A Survey of Astronomy in Britain Between the Two Elizabeths*. London: Bodley Head Ltd., 1967.

A history of astronomy in Britain from the sixteenth to the twentieth century, centering particularly on the famous astronomers who were successively, "astronomers-royal".

126. Sarton, George Leon. *A History of Science*. 2 Vols. Cambridge, Mass.: Harvard University Press. (Vol. I: Ancient Science through the Golden Ages of Greece, 1952; Vol. II: Hellenistic Science and Culture in the Last Three Centuries B.C., 1959)

The first two volumes to be published in an extensive series designed to cover the entire history of science in relation to its cultural background. For advanced students. Fully documented.

127. Schneer, Cecil. *Evolution of Physical Science*. (Original title: *The Search for Order*.) New York: Grove Press, 1964.

An account of the development of physics designed for readers with no special background in physics.

128. Singer, Charles. *The History of Biology*. London: Abelard-Schuman Ltd., 1959.

One of the standard general histories of biology. A brilliant achievement by an artist in the presentation of science history.

129. Singer, Charles. *A Short History of Scientific Ideas to 1900*. London: Oxford University Press, 1959.

A much enlarged and extensively rewritten edition of the author's *A Short History of Science*. It was written, "to give an elementary idea of how science came to occupy its distinctive position in the life of our time."

continued

130. Singer, Charles; Holmyard, E. J.; Hall, A. R.; and Williams, T. L.; eds. *A History of Technology*. 5 Vols. London: Oxford University Press, 1954, 1956, 1957, and 1958.

An outstanding history of the development of man's technical and mechanical skills from the Stone Age to the end of the nineteenth century. Many different specialists have contributed chapters on particular aspects, but the whole is written in plain language, with the minimum of technicalities, and provides a comprehensive, accurate, and very readable record. It is well produced with many illustrations.

131. Taton, Rene, ed. *History of Science*. 4 Vols. New York: Basic Books Inc. (Vol. 1: Ancient and Medieval History, 1963; Vol. 2: Beginnings of Modern Science, 1964; Vol. 3: Science in the Nineteenth Century, 1965; Vol. 4: Science in the Twentieth Century, 1966)
One of the great standard histories of science.

132. Taylor, F. Sherwood. *An Illustrated History of Science*. (Royal Institution Christmas Lectures, 1953.) London: Heinemann Educational Books Ltd., 1955.
Though originally intended for "a juvenile auditory", in their printed form these lectures, with excellent illustrations taking the place of the experiments that accompanied them, provide an admirable introduction to the history of science for readers of all ages. The late Dr. Sherwood Taylor was Director of the Science Museum in London.

133. Taylor, F. Sherwood. *Science Past and Present*. 2nd ed. London: Heinemann Educational Books Ltd., 1962.

A reliable and very readable history of science for the layman. Extracts from important scientific documents of the past, from the Greeks to Herbert Spencer, form an attractive feature.

134. Taylor, G. Rattray. *The Science of Life: A Picture History of Biology*. London: Thames & Hudson, 1963.

Fourteen hundred years of science history, from Aristotle and Da Vinci to the present day.

135. Toulmin, Stephen, and Goodfield, June. *The Architecture of Matter*. The Ancestry of Science Series. London: Hutchinson Publishing Group, 1962.

Traces the development of theories of matter and life from the incantations of ancient witch doctors to relativity, physics, quantum mechanics, and cell chemistry.

136. Toulmin, Stephen, and Goodfield, June. *Fabric of the Heavens*. The Ancestry of Science Series. London: Hutchinson Publishing Group, 1961.

The history of man's conception of the universe.

137. Turner, D. M. *The Book of Scientific Discovery: How Science Has Aided Human Welfare*. 3rd ed. London: George G. Harrap & Co. Ltd., 1960.

A history of all branches of science, intended for students of twelve upwards. It is well written and will appeal also to adult readers.

138. Vaucouleurs, Gerard De. *Discovery of the Universe: An Outline of the History of Astronomy*. Translated by B. Pagel. London: Faber & Faber Ltd., 1957.

A very readable survey of the whole field of astronomy.

139. Walker, Kenneth. *The Story of Medicine*. New York: Oxford University Press, 1955.

A brief history of medicine for the general reader, which follows a historical sequence to the beginning of the modern period and then traces further developments within each major subject area.

140. Whitehead, A. N. *Science and the Modern World*. 2nd ed. London: Cambridge University Press, 1936.

A study of some aspects of western culture during the past three centuries as they have been influenced by the development of science.

141. Whittaker, Edmund. *A History of the Theories of Aether and Electricity*. New York: Humanities Press Inc., 1951. (Vol. I: The Classical Theories; Vol. II: The Modern Theories)

A detailed history of electricity for the specialist. Volume I deals with the period from Descartes to about 1900, Volume II with the period after 1900.

142. Wolf, A. *A History of Science, Technology and Philosophy in the 18th Century*. 2 Vols. Magnolia, Mass.: Peter Smith Publisher Inc.

143. Wolf, A. *A History of Science, Technology and Philosophy in the 16th and 17th Centuries*. 2 Vols. Magnolia, Mass.: Peter Smith Publisher Inc.

A general account of the history of science and technology and their bearing on the philosophy of the period covered. Companion volumes cover the eighteenth century.

Section IV General Topics

144. Abbott, W., ed. *The Young Scientist*. 2 Vols. London: Chatto & Windus Ltd., 1960-63.

A well-illustrated book in which leading experts in their field describe, in informative but simple and straightforward language, many important and exciting branches of modern science.

145. Addison, Herbert. *Land, Water and Food: A Topical Commentary on the Past, Present, and Future of Irrigation, Land Reclamation, and the Food Supplies They Yield*. 2nd ed. London: Chapman & Hall, 1961.

A good all-round picture of an important branch of civil engineering. Irrigation schemes in many parts of the world are described.

146. Alexander, W. O., and Street, A. *Metals in the Service of Man*. New ed. Pelican Series. Harmondsworth, Middlesex, England: Penguin Books, 1969.

An admirably readable account of how metals are obtained, alloys, the inner structure of metals, their shaping, joining, and corrosion, and the part they play in modern life.

147. Allen, Frederick Lewis. *Only Yesterday*. New York: Harper & Row, 1964.

A general account of the famous Scopes Trial.

148. Allen, Gina. *Gold*. New York: Thomas Y. Crowell, 1964.

An account of all aspects of the beguiling metal.

149. Allen, Leslie H., ed. *Bryan and Darrow at Dayton: The Record and Documents of the Bible-Evolution Trial*. New York: Russell & Russell Publishers, 1967.

This account is based largely on court transcriptions of the famous Tennessee monkey trial (the Scopes Trial) in which Bryan prosecuted and Darrow defended the school teacher accused of teaching evolution.

150. Allibone, T. E. *The Release and Use of Atomic Energy*. (Royal Institution Christmas Lectures.) London: Chapman & Hall, 1961.

An introduction to nuclear science, the historical background, theory research, and application. Selected experiments of the last sixty years were reproduced during the lecture on which the book is based and these are described so that other teachers may make use of them.

151. Andrade, E. N. Da C. *A Brief History of the Royal Society*. London: The Royal Society, 1960.

A volume to mark the Society's three hundredth anniversary.

152. Arons, Arnold B., and Bork, Alfred M. *Science and Ideas*. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1964.

A book dealing with science in three major areas: philosophy of science, history of science, science in society. It is a collection of well-written essays on such diverse topics as the value of science, Newton with his prisms, science and human conduct, to name only a few. A useful book for students wishing to acquire a background in science.



153. Asimov, Isaac. *The New Intelligent Man's Guide to Science*. Toronto: University of Toronto Press, 1965.

A general introduction to science by a master in the field of interpreting science to the layman.

154. Baker, H. G. *Plants and Civilisation*. Fundamentals of Botany Series. London: Macmillan & Co. Ltd., 1965.

A summary of the relation between plants and human culture.

155. Barlow, Nora, ed. *Darwin and Henslow: The Growth of an Idea: Letters, 1831-1860*. Berkeley, Calif.: University of California Press, 1967.

The correspondence between Charles Darwin and Professor J. S. Henslow, the foremost botanist of his day, showing how each stimulated the other in his biological thinking.

156. Barnett, Lincoln. *The Universe and Dr. Einstein*. West Caldwell, N.J.: William Morrow & Co. Inc., 1948.

A short, accurate, clear exposition enabling the lay reader to begin to understand the basic laws of time, space, and matter.

157. Barnett, S. A., ed. *A Century of Darwin*. New ed. London: Heinemann Educational Books Ltd., 1962.

Fifteen essays by distinguished contemporary biologists providing a review of subjects explored by Darwin.

158. Baron, A. L. *Man Against Germs*. New York: E. P. Dutton & Co. Inc., 1957.

A popular account of our struggle to understand and master infectious disease.

159. Bates, Marston, and Humphrey, P. S., eds. *The Darwin Reader*. London: Macmillan & Co. Ltd., 1957.

An anthology of extracts from all Darwin's principal writings.

160. Boas, Marie. *The Scientific Renaissance, 1450-1630*. The Rise of Modern Science Series. London: William Collins Sons & Co. Ltd., 1962.

Volume 2 (the first published) in a new series which will cover the history of science from its Greek origins to the twentieth century in eight volumes.

Professor Boas gives a clear and readable account of the exciting developments of the period covered, which include the work of Copernicus, Kepler, Galileo, and Harvey.

161. Bradbury, S. *The Microscope: Past and Present*. Pergamon International Popular Science Series. Oxford, England: Pergamon Press Ltd., 1968.

An abridged and revised version of Bradbury's *Evolution of the Microscope*. It provides a fascinating story of an instrument that has been the valued tool of the scientist and especially of the biologist for more than three hundred years.

162. Brinton, Crane. *The Shaping of Modern Thought*. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1963.

"With sanity, balance and penetration, Dr. Brinton relates scientific rationalism and twentieth-century anti-intellectualism, both products of an age-old tension between the real and the ideal, the practical and the desirable, to the mainstream of Western intellectual history." Well written at a mature level.

163. Brody, B. A., and Capaldi, N., eds. *Science: Men, Methods, Goals*. New York: W. A. Benjamin.

This book is really a "sociology" of science. It is a collection of material illustrating the relation between personality, goal, and methods chosen in scientific research.

164. Brothwell, Don and Patricia. *Food in Antiquity: A Survey of the Diet of Early Peoples*. Ancient Peoples and Places Series. London: Thames & Hudson, 1969.

A summary of knowledge about food sources from pre-historic to classical times, with a survey of the different kinds of food resources and a section on diet and disease. Interestingly written and presented.

165. Brothwell, Don, and Sandison, A. T., eds. *Diseases in Antiquity: A Survey of the Diseases, Injuries and Surgery of Early Populations*. Springfield, Ill.: Charles C. Thomas, 1967.

What diseases did man suffer from and how did he cope with them before the era of modern scientific medicine?



166. Brown, J. J. *The Inventors: Great Ideas in Canadian Enterprise*. Toronto: McClelland & Stewart Ltd., 1967.

A well-illustrated book which discusses the contributions that Canadian inventors have made in the field of science and technology.

167. Burstall, Aubrey F. *Simple Working Models of Historic Machines: Easily Made by the Reader*. Cambridge, Mass.: The M.I.T. Press, 1969.

A collection of descriptions and drawings of historic machines, designed both to introduce them to the reader and to allow the reader to construct them if he wishes. The machines described vary in difficulty but many are well within the capacity of the high school student builder.

168. Carson, Rachel. *Silent Spring*. London: Hamish Hamilton Ltd., 1963.

A famous book that first conferred wide publicity on the potential dangers of chemical pesticides and herbicides.

169. Carter, L. J. *Marvels of Modern Science*. London: Evans Brothers, 1968.

A well-illustrated account of such diverse topics as astronomy, space exploration, transport, medicine, and life. Useful for younger students who wish to do research in an area of this sort.

170. Carthy, J. D., and Ebling, F. J., eds. *The Natural History of Aggression*. New York: Academic Press, 1965.

The author investigates the possible origins in animal behaviour of the habit of aggression.

171. Clagett, Marshall. *Greek Science in Antiquity*. Collier Books. New York: Macmillan Co., 1963.

Although written for "the non-specialist who is beginning the study of the history of science", some knowledge of mathematical principles is assumed. Special attention is given to "the fate of Greek science in late antiquity". The author is a Professor of the History of Science at the University of Wisconsin.

172. Clarke, L. J. *The Craftsman in Textiles*. London: G. Bell & Sons Ltd., 1968.

Useful background information concerning the textile industry and its development.

173. Clay, R. S., and Court, T. H. *The History of the Microscope*. London: Charles Griffin & Co. Ltd., 1932.

A standard history of one of science's basic instruments.

174. Cohen, I. B. *The Birth of a New Physics*. Science Study Series. London: Heinemann Educational Books Ltd., 1961.

An account of the revolution in physics during the sixteenth and seventeenth centuries.

175. Coleman, J. A. *Relativity for the Layman: A Simplified Account of the History, Theory and Proofs of Relativity*. New ed. Harmondsworth, Middlesex, England: Penguin Books, 1969.

For readers with little or no training in mathematics and physics.

176. Compton, A. H. *Atomic Quest: A Personal Narrative*. New York: Oxford University Press, 1956.

A personal account of the development of the atomic bomb by one intimately involved from the first talks about its possibilities to its use against Japan. Dr. Compton writes not only as a brilliant scientist but also as a Christian, and in the final chapter he discusses the moral and humanitarian aspects of the use of the bomb.

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177. Conant, James B. *Science and Common Sense*. New Haven, Conn.: Yale University Press, 1951.

A survey of the strategy and tactics of research scientists demonstrated through selected experiments from the Renaissance to the present day. For the scientifically-minded general reader.

178. Conant, James B., and others. *Harvard Case Histories in Experimental Science*. 2 Vols. Cambridge, Mass.: Harvard University Press, 1957.

Eight case studies showing how important scientific concepts grew out of experimental work. Some are treated historically; in others, the contributions of one or two significant figures are analysed. Topics dealt with in Volume I are Boyle's experiments in pneumatics, the overthrow of the phlogiston theory, development of the concept of temperature and heat, and the atomic molecular theory; in Volume II, plants and the atmosphere, Pasteur and Tyndale's study of spontaneous generation, and the development of the concept of electric charge.

179. Cook, J. Gordon. *Your Guide to Plastics*. Science for Everyman Series. Watford, Herts., England: Merrow Publishing Co. Ltd., 1964.

An explanation of why plastics have achieved such tremendous importance during the last decade or two. The different types of plastics that have taken part in this technical revolution are described.

180. Corner, George W. *A History of the Rockefeller Institute*. New York: Rockefeller University Press, 1964.

A history of the famous American research institute.

181. Cornwall, Ian W., and Maitland, Howard M. *The Making of Man*. New York: E. P. Dutton & Co. Inc., 1961.

A well-written, well-illustrated book dealing with human evolution. It attempts to recapitulate the present state of knowledge on the subject.

182. Crombie, Alistair C. *Medieval and Early Modern Science*. 2 Vols. Cambridge, Mass.: Harvard University Press, 1961. (Vol. 1: Science in the Middle Ages, 5th-13th Centuries; Vol. 2: Science in the Later Middle Ages and Early Modern Times, 13th-17th Centuries)

A detailed and very readable account of medieval science; a book not only for scientists and historians but also for the general reader interested in the growth of ideas.

183. Crombie, Alistair C. *Robert Grosseteste and the Origins of Experimental Science, 1100-1700*. London: Oxford University Press, 1953.

A learned and fully documented work tracing the origins of modern experimental method back to the philosophers of the thirteenth century, and following its development through to Sir Isaac Newton.

184. Crombie, Alistair C., ed. *Scientific Change: Studies of the Conditions for Scientific Discovery and Technical Invention from Antiquity to the Present*. New York: Basic Books Inc., 1963.

The most distinguished men and women in their fields—scientists, mathematicians, sociologists, economists, philosophers, and historians from America, Europe, the U.S.S.R., and Asia—have contributed to this book, which comments on almost every aspect of scientific discovery from the earliest times to the present day.

185. Croome, Angela. *Hovercraft*. New York: Astor-Honor Inc., 1962.

Written for mechanically-minded young people but also appealing to interested adults, the book describes the development of "hovercraft" from Leonardo Da Vinci's ornithopter through autogiros and helicopters to the latest developments in the field in the U.K., U.S.A., U.S.S.R., and elsewhere. Cockerell's invention and its successors are described in detail.

186. Crosland, M. *The Society of Arcueil: A View of French Science at the Time of Napoleon I*. London: Heinemann Educational Books Ltd., 1967.

An instructive contrast between scientific society, then and now.

187. Crowther, J. G. *Discoveries and Inventions of the Twentieth Century*. 5th ed. London: Routledge & Kegan Paul, 1966.

Mr. Crowther has entirely revised and rewritten a book by the late Edward Cressy originally published in 1914, giving a broad and up-to-date survey of twentieth-century technology. Subjects discussed include fuel, power, refrigeration, agricultural research, railways, cars, ships, aircraft, radio, and radar. Written with a minimum of technicalities, this book will appeal to the mechanically-minded general reader.

188. Darlington, C. D. *The Evolution of Man and Society*. London: George Allen & Unwin Ltd., 1969.

An original and unusually complex survey of the history and development of human societies by an exceptionally well-informed geneticist. Professor Darlington brings to bear on the events of world history a range of biological and genetic evidence usually ignored by conventional historians.

189. Darlington, C. D. *Genetics and Man*. (New edition of *Facts of Life*.) London: George Allen & Unwin Ltd., 1964.

What are the human implications of our modern understanding of the laws of heredity?

190. De Beer, G. *Atlas of Evolution*. London: Thomas Nelson & Sons Ltd., 1964.

A rich, lavishly illustrated source of basic information about evolution.

191. De Beer, G., ed. *The Sciences Were Never at War*. London: Thomas Nelson & Sons Ltd., 1960.

The story of co-operation among men of science in Great Britain and France during the years 1690-1814, when their countries were often at war, conveyed in a collection of letters that passed between them.

192. De Camp, L. Sprague. *The Ancient Engineers*. Garden City, N.Y.: Doubleday & Co. Inc., 1960.

An account of ancient engineering achievements, from pyramids and aqueducts to catapults, fortifications, and ships, from the earliest times to the Renaissance.

193. De Kruif, Paul. *Microbe Hunters*. New York: Harcourt Brace Jovanovich Inc., 1932.

A dramatic and romanticized account of the work of some of the pioneer medical microbiologists.

194. Dennis, W. H. *A Hundred Years of Metallurgy*. 100 Years Series. London: Gerald Duckworth & Co. Ltd., 1963.

A record of the changes in metallurgy during the past hundred years. Following an introduction, each of the eight chapters deals with progress in one of the major branches of industry.

195. Dowdeswell, W. H. *The Mechanism of Evolution*. 3rd ed. London: Heinemann Educational Books Ltd., 1963.

A short account of the mechanics of evolution, presenting the classical evidence but also incorporating illustrations based on the study of the small evolutionary changes continuously occurring in populations around us.

196. Dreher, Carl. *Automation: What It Is, How It Works, and Who Can Use It*. New York: W. W. Norton & Co. Inc., 1957.

The message of this lively review is summed up in the slogan carried on one of its humorous illustrations, "Automate or Die".

197. Dürrenmatt, Friedrich. *The Physicists*. Translated by J. Kirkup. Evergreen Books. New York: Grove Press, 1964.

A play by a modern Swiss playwright concerning a group of physicists in a psychiatric clinic. The interaction of personality, fantasy, politics, and scientific ethics is explored.

198. Dyos, H. J., and Aldcroft, D. H. *British Transport: An Economic Survey from the Seventeenth Century to the Twentieth*. Leicester, England: University of Leicester Press, 1969.

A history of Britain's transport from the seventeenth century, told from the economic point of view but with close attention to the technical developments that made the transport revolution possible.

199. Eiseley, Loren. *Darwin's Century: Evolution and the Men Who Discovered It*. Anchor Books. Garden City, N.Y.: Doubleday & Co. Inc., 1958.

Evolution and the men who discovered it is the theme of the book. As well as describing Darwin's work, the author traces the achievements and discoveries of men in many fields of science who paved the way for Darwin.

200. Elwell, F. R. *Atoms and Energy*. Outlines Series. London: Methuen & Co. Ltd., 1958.

A simple explanation of the processes and uses of nuclear fission; written for young people.

201. English, W. *The Textile Industry: An Account of the Early Inventions of Spinning, Weaving, and Knitting Machines*. Industrial Archaeology Series, Volume 4. Harlow, Essex, England: Longman Group Ltd., 1969.

The fascinating story of inventions in the textile industry is told clearly and is well illustrated so that those not familiar with textile machines can readily appreciate the significance of each new development. There are chapters on hand spinning wheels, early carding machines, spinning jenny, Robert's automatic mule, Kay's flying shuttle, Cartwright's lever, Lee's stocking frame, and developments in pattern weaving.

202. Evans, David. *Jet Propulsion*. Young Engineer Series. London: Weidenfeld & Nicolson Educational Ltd. (now Rupert Hart-Davis Educational Publications), 1963.

Traces the development of the jet engine for propelling aircraft and explores how this development has made possible the application of the gas turbine to transport on road, rail, and sea.

203. Ewart, W. D. *Atomic Submarines*. Young Engineer Series. London: Weidenfeld & Nicolson Educational Ltd. (now Rupert Hart-Davis Educational Publications), 1963.

Describes the stage-by-stage growth of the submarine from the famous man-driven vessel of the American War of Independence to the present underwater craft with atomic engines. Reference is made to the possibility of giant, nuclear-powered cargo submarines.

204. Fabun, Don. *The Dynamics of Change*. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1967.

Published by Kaiser Aluminium to commemorate the firm's twentieth anniversary, this is an attractively designed volume that looks ahead at some of the anticipated consequences of rapid technological innovation. Contains valuable sections on automation and leisure.

205. Farrington, Benjamin. *Greek Science: Its Meaning for Us*. New ed. Pelican Series. Harmondsworth, Middlesex, England: Penguin Books, 1969.

206. Farrington, Benjamin. *Science in Antiquity*. 2nd ed. Opus Books. London: Oxford University Press, 1969.

These two books by Professor Farrington cover roughly the same period—from the fifth century B.C. until about the fifth century A.D.—but differ in approach. This volume outlines the development of ancient science in close relation with the history of philosophy. In the Pelican volume (item 205) the author has sought to explore the connections of Greek science with practical life, with techniques, and with the economic basis and productive activity of Greek society.

207. Feather, Norman. *Electricity and Matter*. Edinburgh: Edinburgh University Press, 1968.

Primarily a university-level physics textbook, but the treatment is historical with the development of each concept being traced from its origin to its present status. The treatment of the development of the atomicity of electricity and of the atomic constitution of matter is particularly valuable.

208. Ferguson, Eugene S., ed. *Bibliography of the History of Technology*. Society for the History of Technology Series, No. 5. Cambridge, Mass.: The M.I.T. Press, 1968.

A valuable list of references in the field of history of technology.

209. Gamarekian, S. E. *Metals*. Science in Industry Series. London: Burke Publishing Co. Ltd., 1963.

A well-produced book that illustrates the partnership between science and the metal industry.

210. Garrett, Alfred B. *The Flash of Genius*. New York: Van Nostrand-Reinhold Books, 1963.

A collection of fifty-one key discoveries in the fields of chemistry and physics giving, where possible, the discoverer's own description of the crucial experiment leading to the discovery.

211. Gatewood, W. B., Jr. *Preachers, Pedagogues and Politicians: The Evolution Controversy in North Carolina, 1920-1927*. Chapel Hill, N.C.: University of North Carolina Press, 1966.

An account of events and personalities connected with the famous Scopes Trial.

212. Gernsheim, Helmut and Alison. *The History of Photography: From the Camera Obscura to the Beginning of the Modern Era*. 2nd ed. London: Thames & Hudson, 1969.

A standard history.

213. Gibbs-Smith, C. H. *Sir George Cayley's Aeronautics, 1796-1855*. London: Her Majesty's Stationery Office, 1962.

Describes, with the aid of many illustrations and quotations, Cayley's fundamental contributions to aeronautics, both theoretical and experimental, and substantiates the claim that he is the inventor of the aeroplane and the founder of aeronautics.

214. Gibbs-Smith, C. H. *The Wright Brothers: A Brief Account of Their Work, 1899-1911*. London: Her Majesty's Stationery Office, 1963.

Outlines the Wrights' epoch-making achievements from their first bi-plane model of 1899, through their conquest of the air in 1903-05, on to their sophisticated machines of 1910-11. Also shows their decisive role in instigating the rebirth of European aviation during 1902-08.

215. Goodman, L. London. *Automation*. Young Engineer Series. London: Weidenfeld & Nicolson Educational Ltd. (now Rupert Hart-Davis Educational Publications), 1962.

An introduction to the subject of automation, giving details of the latest developments.

216. Greenberg, D. S. *The Politics of American Science*. Harmondsworth, Middlesex, England: Penguin Books, 1969.

Fascinating and well-written accounts of the history of support for American science and of how this support is obtained.

217. Greene, John C. *The Death of Adam: Evolution and Its Impact on Western Thought*. New American Library of World Literature Series. Mentor Books. New York: New American Library Inc., 1961

A fascinating essay on the history of ideas, tracing the rise of the idea of evolution and the decline of the idea of creation in the period from Newton to Darwin.

218. Groueff, Stephane. *Manhattan Project: The Untold Story of the Making of the Atomic Bomb*. Boston, Mass.: Little, Brown & Co., 1967.

A popular account of the famous "Manhattan Project" and the making of the world's first atomic bomb.

219. Hammond, Rolt. *Power Stations Work Like This*. Science Works Like This Series. London: Phoenix House, 1960.

Introduces teenage readers to the general principles and planning of power stations.

220. Harper, Dorothy. *Isotopes in Action*. Commonwealth Library. Oxford: Pergamon Press Ltd., 1963.

A simply-written, well-illustrated book, tracing the development of atomic energy from its origins through to the present time.

221. Hartley, Harold, ed. *The Royal Society: Its Origins and Founders*. London: The Royal Society, 1960.

Biographical sketches of the twelve founding members of the Royal Society and others who played a prominent part in its early days.

continued

222. Hoffmann, Baresh. *The Strange Story of the Quantum*. Pelican Series. Harmondsworth, Middlesex, England: Penguin Books, 1963.

The twentieth-century revolution in physics described in non-mathematical terms.

223. Hooper, Alfred. *Makers of Mathematics*. London: Faber & Faber Ltd., 1961.

A very readable history of the development of mathematical science for the general reader.

224. Howard-White, F. B. *Nickel: An Historical Review*. New York: Van Nostrand-Reinhold Books, 1963.

An account of the development of nickel from early times to the present day, with incidental portraits of the men who built up the industry. Contains a survey of the applications of nickel today, including references to nickel silver, electroplating, the steel field, and its hundred-and-one uses in industry, architecture, and in the home.

225. Hunter, Leslie. *Coal*. Science in Industry Series. London: Burke Publishing Co. Ltd., 1961.

226. Hunter, Leslie. *Electricity*. Science in Industry Series. London: Burke Publishing Co. Ltd., 1963.

227. Hunter, Leslie. *Oil*. Science in Industry Series. London: Burke Publishing Co. Ltd., 1961.

This and the two preceding books form part of a lavishly illustrated series, each volume of which describes the partnership between science and a particular industry.

228. Ihde, Aaron J., and Kieffer, W. F., eds. *Selected Readings in the History of Chemistry*. Easton, Pa.: Chemical Education Publishing Co., 1965.

Reprints of articles that have appeared in the *Journal of Chemical Education*.

229. Jay, Kenneth, and Gibbons, Gerard. *British Nuclear Reactors*. London: Chatto & Windus Ltd., 1960.

A simple, straightforward outline of atomic energy at work, with clear diagrams, many in colour. Intended for young readers, the book should also interest the non-technically minded adult.

230. Jolley, E. H. *Telecommunications*. Young Engineer Series. London: Weidenfeld & Nicolson Educational Ltd. (now Rupert Hart-Davis Educational Publications), 1963.

The story of telecommunications from the introduction of the electric telegraph in the 1830s.

231. Jungk, Robert. *Brighter Than a Thousand Suns*. Pelican Series. Harmondsworth, Middlesex, England: Penguin Books, 1960.

The development of the atomic bomb is traced in this history which emphasizes the moral and political attitudes of the atomic scientists.

232. King, Henry C. *The History of the Telescope*. London: Charles Griffin & Co. Ltd., 1955.

A standard history which traces the evolution of the telescope and includes interesting information about the craftsmen and instrument-makers concerned as well as an outline of the many advances in astronomy made possible by successive developments.

233. Kipphardt, H. *In the Matter of J. Robert Oppenheimer*. Translated by J. Roberts. Modern Plays Series. London: Methuen & Co. Ltd., 1967.

The text of a successful Broadway play based on the investigation of Robert Oppenheimer by an American congressional committee.

234. Kline, Morris. *Mathematics in Western Culture*. New York: Oxford University Press, 1953.

A valuable contribution to the study of the relation between science and humanities. Mathematical knowledge is not required for appreciation of this account of the influence of mathematics on philosophy, the physical and social sciences, literature, and the arts.

235. Kramer, Edna E. *Main Stream of Mathematics*. New York: Oxford University Press, 1951.

A history of mathematics intended for the general reader with a grounding in technique.

236. Kramish, Arnold. *Atomic Energy in the Soviet Union*. Stanford, Calif.: Stanford University Press, 1959.

A review by an American of the history, scope, and future possibilities of Soviet nuclear research and development, based on information from Russian newspapers and technical journals.

237. Kuhn, Thomas S. *The Structure of Scientific Revolutions*. 2nd ed. Phoenix Books. Chicago: University of Chicago Press, 1970.

A brilliant and scholarly analysis of the nature, causes, and consequences of revolution in basic scientific concepts.

238. Lack, D. *Darwin's Finches: An Essay on the General Biological Theory of Evolution*. Magnolia, Mass.: Peter Smith Publisher Inc.

An account of the finches of the Galapagos Islands, the observation of which by Darwin during the voyage of the *Beagle* was germinal in establishing the idea of natural selection as a means of evolution.

239. Lack, D. *Evolutionary Theory and Christian Belief*. New ed. London: Methuen & Co. Ltd., 1957.

The controversy between "Darwinism" and Christianity is restated and re-examined by a distinguished ornithologist.

240. Landau, L. D., and Rumer, G.B. *What Is Relativity?* Translated by N. Kemmer. Edinburgh: Oliver & Boyd Ltd., 1960.

A brilliant simplification by two leading Russian scientists requiring no technical knowledge beyond arithmetic.

241. Larsen, Egon. *A History of Invention*. 2nd ed. London: J.M. Dent & Sons Ltd., 1969.

A popular account of technical progress under three headings: Energy, Transport, Communications.

242. Larsen, Egon. *Transport*. Progress of Science Series. London: Phoenix House, 1959.

A survey of the development of transportation.

243. Latham, B. *Wood from Forest to Man*. London: George G. Harrap & Co. Ltd., 1964.

A short book explaining various kinds of wood, their uses, places of origin, and some historical data concerning the lumbering industry.

244. Lawrence, Jerome, and Lee, R.E. *Inherit the Wind*. Pathfinder Books. New York: Bantam Books Inc., 1968.

The text of a Broadway play, later a successful film, based on the famous Tennessee trial (Scopes Trial) of a teacher accused of teaching evolution.

245. Lister, R. *Great Craftsmen*. London: G. Bell & Sons Ltd., 1962.

A simply written book offering detailed biographies of craftsmen who have made contributions to crafts such as furniture making, pottery, and musical instruments. Such people as Benvenuto Cellini, the clockmaker Thomas Tampion, and the violin-maker Antonio Stradavarius are discussed.

246. Livingston, M. Stanley. *Particle Accelerators: A Brief History*. Cambridge, Mass.: Harvard University Press, 1969.

A concise, simple, and authoritative account of the technical history of accelerator development from Cockcroft and Walton to the U.S. Congress Bill of 1968 authorizing construction of a 200-GeV accelerator.

247. Medawar, Peter B. *Induction and Intuition in Scientific Thought*. Memoirs Series, Vol. 75. Philadelphia, Pa.: American Philosophical Society, 1969.

A clear, incisive, and elegant formulation of the idea that the traditional description of scientific methodology as the apotheosis of inductive reasoning is inadequate and overlooked in the practice of science.

248. Michel, Henri. *Scientific Instruments in Art and History*. Translated by R. E. W. Maddison and Francis R. Maddison. New York: The Viking Press Inc., 1967.

A colourful, well-illustrated book containing diagrams and pictures of scientific instruments of war and peace. A useful source book.

249. Moorehead, Alan. *Darwin and the Beagle*. London: Hamish Hamilton Ltd., 1969.

A masterfully written and produced account of Darwin's voyage around the world in the *Beagle*.

250. Nelson, William R., ed. *The Politics of Science: Readings in Science, Technology and Government*. New York: Oxford University Press, 1968.

A source book of material relating to the political management of science and technology.

251. Odle, F. *The Picture Story of British Inventions*. Manchester: World Distributors (Manchester) Ltd., 1966.

A well-illustrated book containing bibliographical and technical information on the great inventors of Great Britain. Both scientific and technological matters are discussed.

252. Parsons, W.B. *Engineers and Engineering of the Renaissance*. Cambridge, Mass.: The M.I.T. Press, 1968.

A splendidly illustrated account of the engineering achievements of the Renaissance, with numerous extended quotations from original sources.

253. Pinto, E.H. *The Craftsman in Wood*. London: G. Bell & Sons Ltd., 1962.

A well-written book covering such topics as the evolution of woodworking, a wood for every purpose, the worker in veneer and his palette, and the furniture craftsman. Of particular value to people interested in woodworking and furniture design and development.

254. Purcell, John. *The Best-Kept Secret: The Story of the Atomic Bomb*. New York: Vanguard Press, 1963.

A history of the development of the atomic bomb.

255. Romer, Alfred, ed. *The Discovery of Radioactivity and Transmutation*. New York: Dover Publications Inc., 1965.

A historical account of one of the most significant phases of modern scientific research, leading directly to our knowledge of the structure of the atom and its nucleus.

256. Rose, J. *Automation: Its Uses and Consequences*. Contemporary Science Publications. Edinburgh: Oliver & Boyd Ltd., 1967.

This well-written book deals with the impact of automation on the social, commercial, and industrial elements of our society.

257. Rostand, Jean. *Can Man Be Modified?* New York: Basic Books Inc., 1959.

A non-technical discussion of the possibilities of using our genetic knowledge to modify our own species in a predetermined way.

258. Russell, Bertrand. *The ABC of Relativity*. 2nd ed. Edited by F. Pirani. London: George Allen & Unwin Ltd., 1958.

Lord Russell gradually introduces the principles of relativity and explains their practical application.

259. Santillana, Giorgio De. *The Crime of Galileo*. Mercury Books. London: Heinemann Educational Books Ltd., 1961.

A scholarly account of the dramatic trial of Galileo and the political, religious, and scientific issues involved, by the Professor of History and Philosophy of Science at the Massachusetts Institute of Technology.

260. Schonland, B.F.J. *The Atomists, 1805-1933*. London: Oxford University Press, 1968.

The author traces the history of the idea of the atom from the beginning of the nineteenth century up to the climax of the 1930s and shows that the development of the modern concept was a continuous and logical one.

261. Seaborg, Glenn T., and Valeus, Evans G. *Elements of the Universe*. New York: E.P. Dutton & Co. Inc., 1958.

A well-illustrated book written for the layman who wishes to have a general knowledge of matters related to atomic theory, the universe, and some elementary astronomy.

262. Semler, E.G., ed. *Engineering Heritage: Highlights from the History of Mechanical Engineering*. 2 Vols. London: Heinemann Educational Books Ltd., 1966.

Each volume contains twenty-six articles by various authors dealing with some outstanding development in mechanical engineering. Some articles are biographical, others deal with a specific incident. The general tone is journalistic and non-technical.

263. Sharlin, Harold I. *The Making of the Electrical Age: From the Telegraph to Automation*. Life of Science Library Series. London: Abelard-Schuman Ltd., 1964.

Records the history of a force that has shaped the structure of modern civilization.

264. Simpson, George Gaylord. *The Meaning of Evolution: A Study of the History of Life and of Its Significance for Man*. Rev. ed. New Haven, Conn.: Yale University Press, 1967.

A general work on the meaning of evolution, explaining the forces that brought it about and tracing the evolutionary history of the major groups of living things.

265. Smeltzer, D. *Man and Number*. London: A. & C. Black Ltd., 1953.

A short account of the growth of "man's appreciation and use of number . . . of the social and practical influences which have affected that growth, and of the place of number in the development of man's way of life." Only elementary mathematical knowledge is required.

266. Smith, H. Shirley. *The World's Great Bridges*. New ed. London: Phoenix House, 1964.

A delightful history of bridge building through the ages and in many countries. Mr. Shirley Smith is the director of a British firm of bridge builders and has been associated with the construction of many modern bridges.

267. Smith, J. Eric, ed. *Torrey Canyon Pollution and Marine Life*. A Report by the Plymouth Laboratory of the Marine Biological Association of the United Kingdom. London: Cambridge University Press, 1968.

A book about pollution which describes the effects of oil leakage from the supertanker *Torrey Canyon*.

268. Snow, Charles P. *Science and Government*. New American Library of World Literature Series. Mentor Books. New York: New American Library Inc., 1962.

An account of the rivalry between Sir Winston Churchill's two top scientific advisers during World War II, Sir Henry Tizard and F.A. Lindermann (Lord Cherwell), and how it affected some of the momentous governmental decisions of the period.

269. Snow, Charles P. *Two Cultures and a Second Look*. (Original title: "The Two Cultures and the Scientific Revolution".) London: Cambridge University Press, 1964.

A reprint of the lecture in which C.P. Snow first developed his famous "two cultures" thesis of the dichotomy in thought and background between scientist and humanist.

270. Snyder, Louis L., and others. *Panorama of the Past: Readings in World History*. 2 Vols. Boston: Houghton Mifflin Co., 1966. (Vol. 1: Ancient Times to 1815; Vol. 2: 1815 to the Present)

271. Snyder, Louis L., ed. *The Imperialism Reader*. New York: Van Nostrand-Reinhold Books, 1962.

This book and the one preceding (item 270) are collections of original sources designed for the use of students to supplement the usual textbook accounts.

272. Stavrianos, Leften S., ed. *The Epic of Modern Man: A Collection of Readings*. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1966.

Similar to items 270 and 271.

continued

273. Steeds, W. *A History of Machine Tools, 1700-1910* London: Oxford University Press, 1969.

A history of the development of the major types of machine tools from their origins in the beginning of the Industrial Revolution. Lavishly illustrated.

274. Stern, Curt, and Sherwood, Eva R., eds. *The Origin of Genetics: A Mendel Source Book*. San Francisco: W.H. Freeman & Co., 1966.

Traces the origin of modern genetics and in particular the contribution of Gregor Mendel.

275. Stocking, George W., Jr. *Race, Culture and Evolution: Essays in the History of Anthropology*. New York: Free Press (orders to Macmillan Co.), 1968.

This book deals with race, culture, and evolution as the three major concepts of anthropology. between 1800 and 1930. The book provides excellent resource material for those who wish more information and new insights into these problems.

276. Struik, D.J. *A Concise History of Mathematics*. London: G. Bell & Sons Ltd., 1954.

A highly condensed survey of the history of mathematics from the neolithic age to the nineteenth century, covering developments in Egyptian, Babylonian, Chinese, Indian, Greek, Arabian, and Western mathematics.

277. Sutton, G. *Mathematics in Action*. London: G. Bell & Sons Ltd., 1954.

A book dealing with the impact of modern mathematical ideas on modern notions about the universe. This book would be useful to students who have an interest in and background knowledge of modern mathematics.

278. Taylor, E.G.R. *The Mathematical Practitioners of Hanoverian England, 1714-1840*. London: Cambridge University Press, 1966.

An account of relations among the mathematicians of Hanoverian England, providing an interesting contrast to the social organization of modern science.

289. Theobald, D.W. *An Introduction to the Philosophy of Science*. London: Methuen & Co. Ltd., 1968.

A maturely written book dealing with the thesis that "science is an evolving language-system". This thesis is used to construct a coherent picture of the scientific enterprise. Various aspects of the subject are dealt with from this viewpoint: facts and theories, explanations and descriptions, scientific laws, probability, the relations between the sciences, scientific change, and the nature of physical reality.

280. Thorpe, W.H. *Science, Man and Morals*. London: Methuen & Co. Ltd., 1965.

General biology, genetics, ethnology, and biophysics as they affect man's view of his own nature and of his ethical and moral sense. It is a maturely written book dealing with philosophical issues relating to both science and religion.

281. Tompkins, Jerry R., ed. *D-Days at Dayton: Reflections on the Scopes Trial*. Baton Rouge, Louisiana: Louisiana State University Press, 1965.

An account of the famous Tennessee "Monkey Trial" (the Scopes Trial) and its background. It reprints the text of the Tennessee Anti-Evolution Act.

282. Turnbull, H.W. *The Great Mathematicians*. University Publications. London: Methuen & Co. Ltd., 1962.

A biographical history of mathematics from Thales and Pythagoras in the sixth century B.C. to the great mathematical pioneers of our own century.

283. Usher, Abbott P. *A History of Mechanical Inventions*. Rev. ed. Cambridge, Mass.: Harvard University Press, 1954.

First published in 1929. A broad survey of the production and control of power in general and of a number of particular operations, including textile manufacture, water mills and windmills, the use of steam and of the lathe, the invention and development of printing.

284. Walker, Marshall. *The Nature of Scientific Thought*. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1963.

"Marshall Walker offers here an orientation rather than a treatise, illustrating the inherent unity of all science. He provides an exciting explanation of the classic techniques common to all fields of research; concepts, categories, postulates, models, measurements, experimental observation; extending them to include many aspects of everyday life, such as ethics and education." A useful book for those desiring a general scientific orientation.

285. Walton, H. *The How and Why of Mechanical Movement*. New York: E.P. Dutton & Co. Inc., 1968.

A well-illustrated book useful to teachers and students who want to learn more about the principles of movement underlying the development of pulleys, levers, pistons, gearing, drive shafts, and the like.

286. Weeks, Mary E. *Discovery of the Elements*. Edited by H. M. Leicester. 7th ed. Easton, Pa.: Chemical Education Publishing Co., 1968.

Recounts the often intriguing stories surrounding the discovery of the chemical elements.

287. Westfall, Richard S., and Moren, Victor E., eds. *Steps in the Scientific Tradition*. New York: John Wiley & Sons, 1968.

A useful source of documents that might not readily be available, such as the writings of Aristotle, Ptolemy, Lucretius, Harvey, Lavoisier, Sadi Carnot, Charles Darwin, Thomas Hunt, Morgan, and many others. A useful book for students who wish to make reference to such documents.

288. Wheelhouse, F. *Digging Stick to Rotary Hoe*. London: Cassell & Co. Ltd., 1967.

A history of agricultural implements.

289. White, K. D. *Agricultural Implements of the Roman World*. London: Cambridge University Press, 1967.

290. White, Lynn, Jr. *Medieval Technology and Social Change*. Oxford Publications. London: Oxford University Press, 1962.

An outstanding study that examines the role of technological innovation in the rise of social groups during the Middle Ages. The major topics discussed are the stirrup and its relation to feudalism and chivalry, the agricultural revolution of the early Middle Ages and the effect of improvements in the plough, the discovery of horse power and three-field rotation of crops, and the medieval exploration of mechanical power and devices.

291. Williams, Greer. *Virus Hunters*. New York: Alfred A. Knopf, Inc., 1959.

An informal history of the discovery and study of the viruses.

292. Woodbury, Robert S. *History of the Lathe to 1850: A Study in the Growth of a Technical Element of an Industrial Economy*. Society for the History of Technology Series, No. 1. Cambridge, Mass.: The M.I.T. Press, 1961.

293. Zinsser, Hans. *Rats, Lice and History*. Boston, Mass.: Little, Brown & Co., 1935.

Written in a highly individualistic and dramatic style, this is an informal history of the effects through the ages of the great typhus plagues.

Part 2 — Periodicals

As in all other branches of science, there are special journals devoted to the history and philosophy of science and technology and to the impact of science and technology on contemporary life. In addition, many of the general scientific journals, both those for the professional and the layman or for the scientist in fields other than his own, regularly contain articles in the fields of interest of courses in Man, Science, and Technology.

A few examples in each category are listed. They are only a selection from the wide range available.

Nature: International Journal of Science. Macmillan (Journals) Ltd., Subscription Department, Brunel Road, Basingstoke, Hampshire, England. (published weekly)

This is perhaps the best known of all scientific journals. It publishes articles and original research in all branches of science. Because it appears each week, it has been and continues to be the journal in which scientists first announce new discoveries resulting from their research. These announcements are often in the form of very short articles called "Letters to the Editor", and a report on the work often appears later in longer and more detailed form in one of the more specialized journals. Each issue also contains a smaller number of longer articles of a review nature, or developing some new idea at length. These are often written by leading figures in the various fields.

These articles and the shorter "Letters" are generally too technical for the student or layman. Each issue, however, contains an opening section by the editors which summarizes the week's events in the politics and management of science, and in science education, both in Europe and throughout the world. There is perhaps no better summary of the current interactions of science, government, education, business, and the public. These sections can be read without a technical or scientific background and will provide a wealth of information on all the current public issues in science and technology.

The editors also provide a continuous summary of research findings in fields of current interest. Often these act as a layman's guide to the significance of the more important announcements appearing in the body of the journal. There are occasional articles on the history and philosophy of science, and each issue contains reviews of newly published books in all fields of science. Regular perusal of these reviews is the best possible way of identifying books that would be of interest in Man, Science, and Technology courses.

Despite the technical nature of much of its material, no other journal can give the layman so panoramic a picture of modern science or so great a "feel" for its spirit and nature.

Science. American Association for the Advancement of Science, 1515 Massachusetts Avenue N.W., Washington, D.C. 20005 (published weekly)

Science is the American counterpart of *Nature*. It has much the same general makeup, including both technical research articles and non-technical comment on current issues. *Nature* is more international in outlook although it has a British flavour; *Science* has an American flavour and tends to concentrate on American research and issues. In general, however, much the same comments apply to *Science* as to *Nature*.



Science Forum: A Canadian Journal of Science and Technology. University of Toronto Press, Front Campus, University of Toronto, Toronto 181. (published every second month)

Science Forum does not, like *Nature* and *Science*, publish original research. Its articles tend to be of the review type, written by experts but summarizing the results of research in fields of current interest in language accessible to the layman. A large proportion of its articles deal with the support, management, and sociology of science. It is the best source of material of immediate Canadian interest.

New Scientist. New Science Publications, 128 Long Acre, London WC2, England. (published weekly)

New Scientist publishes general articles reviewing progress in areas of current interest in both science and technology. These are in non-technical language and written in an easy journalistic style designed to appeal to the interested layman or to the scientist or engineer reading in a field other than his own. As in *Science Forum*, many articles deal not with the findings of science, but with the political, commercial, educational, and sociological aspects of contemporary science and technology. The range of interest is international, but the emphasis and most of the writers are British.

Scientific American. Scientific American Inc., 415 Madison Avenue, New York, N.Y. 10017. (published monthly)

This is the oldest and best of the journals whose aim is to explain in clear language, free from undefined jargon, the results of recent research in significant areas of science and technology. The articles are by leading men in their fields from all over the world, although with Americans predominating. They are outstandingly illustrated and well edited. There are excellent book reviews although the coverage is not as complete as in *Nature* or *Science* and, as in *Nature* and *Science*, there is a continuous editorial summary of research and commentary on current issues. The student or teacher who needs to "get up" a particular topic will seldom find a better short presentation than in the appropriate *Scientific American* article. Many of these articles are available at low cost as separate off-prints (List of currently available *Scientific American* off-prints is available from W. H. Freeman & Co., 660 Market Street, San Francisco, California 94104.)

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Bulletin of the Atomic Scientists: Science and Public Affairs. Published by the Educational Foundation for Nuclear Science with the co-operation of the Adlai Stevenson Institute of International Affairs. Assisted by the Center for the Study of Science and Society, State University of New York, Albany. Available from: Bulletin of the Atomic Scientists, Circulation Department, 935 East 60th Street, Chicago, Illinois 60637. (published monthly ten times a year) The title and sponsors of this journal indicate accurately its field of interest. Articles are completely non-technical and deal entirely with the human implications of contemporary science and technology. Virtually every current issue arising from the use or abuse of scientific or technological developments is thoroughly dealt with. The major object of the journal is to promote public awareness of the human implications of these developments.

Annals of Science: A Quarterly Review of the History of Science and Technology Since the Renaissance. Taylor & Francis Ltd., 18 Red Lion Court, Fleet Street, London EC4, England.

A scholarly journal that publishes original papers, correspondence, and reviews of books on the history of science and technology since the Renaissance.

The British Journal for the History of Science. The British Society for the History of Science. Available from: The Science Museum, South Kensington, London SW7, England. (published bi-yearly)

A scholarly journal, written by and for specialists in the field and similar to *Annals of Science* in its approach.

Journal for the History of Astronomy. MacDonald & Co. Ltd., 49 Poland Street, London W1A, England. (published bi-yearly)

A scholarly journal devoted to the history of astronomy, astrophysics, and cosmology from the early civilizations to the present day. Its subject matter extends into such allied fields as the history of navigation, timekeeping, and geography, as well as the history of the relevant branches of mathematics and physics.

Studies in History and Philosophy of Science. Macmillan (Journals) Ltd., Subscription Department, Brunel Road, Basingstoke, Hampshire, England. (published quarterly)

This is a relatively new scholarly journal whose intention is to analyse the genesis, evolution, and logic of scientific thought. It hopes to avoid the artificial academic divisions which have traditionally hindered a unified approach to the development of science.

Isis: An International Review Devoted to the History of Science and Its Cultural Influences. The official journal of the History of Science Society. Available from: The Periodicals Department, University of California Press, 2223 Fulton Street, Berkeley, California 94720. (published quarterly)

A scholarly journal whose field of interest is well indicated by its title, this is an American counterpart to *Annals of Science*, *The British Journal for the History of Science*, and the *Journal for the History of Astronomy*.

Technology and Culture: The International Quarterly of the Society for the History of Technology. University of Chicago Press, 5750 Ellis Avenue, Chicago, Illinois 60637.

This journal deals more specifically than the others with the history of technology as distinct from that of science. Again, it is a scholarly journal written by and for scholars in the field.

